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Editorial.

The German Radio and Phono Exhibition.

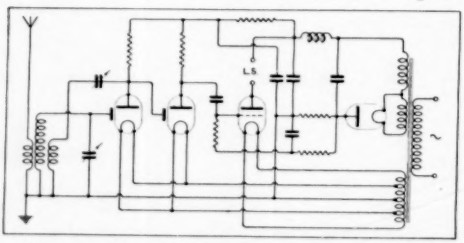
THE Annual Radio Exhibition which was held in Berlin from 22nd to 31st August was this year for the first time combined with a Gramophone Exhibition. Recent developments in both industries made such a combination desirable and almost inevitable. Berlin is specially fortunate—or perhaps it would be more correct to say specially wise—in the facilities available for holding exhibitions, but it is a striking fact that the most spacious of the three blocks of exhibition buildings which stand in the area set apart by the city for exhibition purposes has been built and is owned by the German Wireless Industry, who hire it out for other exhibitions when they do not require it themselves. The original hall, which we described and illustrated four years ago, was constructed of wood so that the exhibitors could pick up external broadcast programmes by means of internal aerials in order to demonstrate their apparatus operating loud speakers in the numerous sound-proof rooms which surround the hall. The buildings have since been so extended that this original hall forms but a part of one side of a square of exhibition halls; the well-known Funkturm, with its elevated restaurant, standing within the quadrangle and forming a landmark and advertisement visible—and audible when the giant loud speaker at its summit was operating—for miles around. It was a striking commentary on the developments of the last four years, and perhaps an evidence of the wisdom of the exhibitors, that no aerial was to be seen in the building, practically all the demonstrations of loud speakers being provided by gramophone records. There were very few attempts to demonstrate the performance of the radio end of the apparatus. The exhibition was of a strictly national character, no foreign firms or foreign apparatus being admitted. It was not merely a trade exhibition; several of the halls being fitted out by the Government and Broadcasting Company with historical and cultural exhibits arranged on a very liberal and spacious scale. The visitor could thus follow the development of sound recording and reproduction from the first crude machine made by Edison down to the latest phase of the talking film, and could listen to the voices of scientists and statesmen, some of whom are still living and some of whom have passed away.

Of the trade section, which after all was the *raison d'être* of the Exhibition, the outstanding feature was the great improvement both

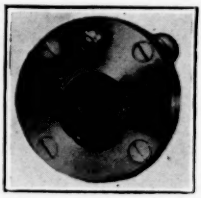
internally and externally in the sets made by most of the leading firms. Fifty cycle alternating current is more general in Germany than in this country, and all-mains sets for plugging in to such a supply formed the larger part of the sets exhibited. Only a few firms exhibited portable sets, but in one of these we noticed special arrangements provided for cutting out the batteries and using the A.C. supply when operating the set at home.

Probably the greatest novelty was the gridless valve with the external control electrode. This is a very old idea, as de Forest tried it and patented it a year before it occurred to him to insert the grid between the filament and the anode. With the ordinary shape of valve the control exerted by a band of tinfoil wrapped around the valve is very small, or, in other words, the amplification is small. This has been overcome by making the bulb in the form of a cylindrical tube squashed almost flat, with the filament running up in one corner and the anode in the other. The control electrode is in the form of a metal coating sprayed on to the outside of the tube. It is thus quite close to the filament, being separated from it by the glass wall and the clearance between the glass and the filament. It is impossible to take static characteristics of these valves because, when a positive potential is applied to the coating, its effect is neutralised by the layer of electrons which gradually forms on the inside of the glass. For the same reason grid bias voltage has no effect and there is no need to insert a condenser between the coating and the anode of the previous valve. If there are positive gas ions in the tube these will gradually form a neutralising inner layer when a negative potential is applied to the outer coating; the valve will respond, however, to alternating voltages. The leakage resistance of the glass wall is an important factor in the operation, taking the place of the grid-leak in the detector with grid rectification. It is found that for rectification soft valves are preferable, whereas for low-frequency amplification a high vacuum is better. Two types are therefore made, and known respectively as Arcotron 201 (hard) and 301 (soft). They are not suitable for high-frequency amplification. They have the advantage of direct heating of the filaments with alternating current without any appreciable hum, although the filament current is only 0.2 ampere at 1 volt. We understand that these valves are only being used in relatively cheap sets, such as the Telefunken 12 W, a 3-valve (det. and 2 l.f.) all-mains set, complete with built-in loud speaker, retailing at eight guineas. It is interesting to note that the Telefunken Company do not make a set with a single high-frequency stage, as they maintain that satisfactory selectivity cannot be obtained with less than two stages. Other German firms, however, do make 3-valve sets with a single high-frequency stage; the Loewe Company making such a set incorporating their three valves in one, all-mains, with built-in loud speaker, to retail at £6 5s.

The Arcotron valve showing size compared with the hand.



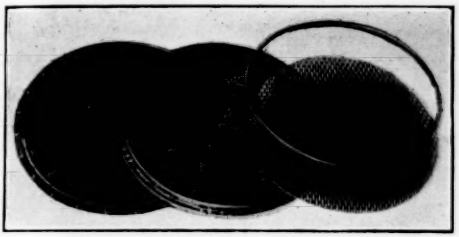
Circuit of a Telefunken all-mains set which employs two Arcotron valves, one as detector and one as L.F. amplifier.



Copper oxide photo electric cell. A new product shown at the Exhibition.

Among the enormous number of loud speakers the most interesting was probably the improved electrostatic type which has been designed by Hans Vogt, and which is being made in Germany by the Blue Spot Ideal

Company. The metal diaphragm, about a foot in diameter, is stated to be about a thousandth of a millimetre thick ; this is strained between two perforated bakelite discs, the graphited faces of which are about 2 mm.



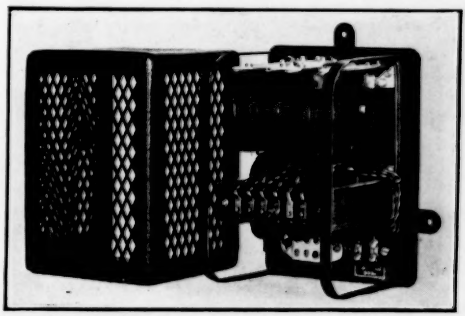
The Hans Vogt Electrostatic Loud Speaker dismantled to show construction.

apart. The polarising potential of about 800 volts is obtained from a special hard rectifying valve. The perforations in the discs vary in size ; near the centre, where the amplitude of the diaphragm is largest, the perforations are small, and the air cushioning effect therefore very large. So far as one could judge under Exhibition conditions the results obtained were excellent, and we feel sure that the electrostatic type of loud speaker will take its place as a worthy rival to the electromagnetic and electrodynamic types.

An interesting short-wave receiver was shown by the Telefunken Company. In this they depart from their policy of avoiding a single high-frequency stage, for it is a straightforward 3-valve set (h.f., det., l.f.) with which it is claimed short-wave signals from America can be received. It is made in two types, one for the range 13.9–100 metres and the other for 13.9—50 and 200—550 metres. The inductance is changed by means of a 5-way switch ; the condenser rotor snaps into one of twelve definite positions ; the stator of the condenser is then moved through about 15 degrees by means of a geared knob which rotates through 360 degrees for each one of the 60 ranges. It is claimed that the set can be accurately calibrated and that the calibration is independent of the aerial.

An interesting scientific exhibit was Dr. Kohl's demonstration of telephony by means of waves of 14 cm. length, that is, a frequency of over 2,000 million cycles per second. The oscillations were produced inside the valve by the Barkhausen and Kurz method ; the valve was placed at the focus of a parabolic metallic mirror about 18 inches diameter, and the anode supply was modulated by a gramophone record. The reception was obtained by a similar mirror and valve about 20 feet way. By means of a wire grating and a large metal sheet, polarisation and reflection were demonstrated. It was stated that satisfactory results had been obtained over several kilometres.

A section of the Exhibition was devoted to the education of the public in the matter of the disturbance caused to broadcast reception by electric power apparatus such as motors, vacuum cleaners, medical apparatus, electric trams and railways. In large con-



Selenium Rectifier with an output of 0.35 ampere.

gested cities, where the use of electric power is very general, considerable interference is produced by such apparatus, and the German authorities are conducting a vigorous campaign with the object of reducing the disturbance by connecting choking coils and condensers in the circuits of the offending apparatus. The trouble has, of course, been intensified by the introduction of the all-mains set. G.W.O.H.

The British Radio Exhibition, held at Olympia, September 19th to 27th, will be dealt with in our next issue.

On the Theory of Filter Amplifiers.*

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THE orthodox theory of electrical wave filters has been admirably presented by Mr. M. Reed in recent numbers of *E.W. & W.E.* (p. 122, March, 1930 *et seq*), and it is not proposed in the present Paper to add to or to repeat any of that theory. In this work the problem of electrical filtering is attacked from a new angle in which use is made of systems of simple filter units separated by valves so that we combine in one amplifier the property of filtering with that of amplification. The simple units employed can, in the case of low pass filters, be so designed that they take up little more space than the anode resistance employed in the ordinary straight resistance capacity amplifier. The writer has constructed filter units in which the resistances and inductances are wound round a cylinder of length 3in. and diameter 1¼in., while the necessary condensers are contained within the core of the cylinder. Units so constructed can be made of the plug-in type to admit of ready replacement. In the case of band pass filters it should be possible to design the intervalve system so as to have all the elements on two such cylindrical units. It is therefore clear that it is possible to obtain compact filter amplifier systems even if the degree of amplification is pushed to many stages.

The theory given below has been embodied in a set of design tables so that the task of the designer is reduced to as small proportions as possible.

Apart from the compactness of the system the filter amplifier has an advantage over the orthodox filter systems in that the effect of resistance is under complete control so that we may construct filters in which the sensitivity is uniform in the pass region.

1. General Scheme.

An ideal electrical filter should not only completely reject the unwanted frequencies but should also have uniform sensitivity for the wanted frequencies. In the usual type of filter circuit, the first condition is generally approximately fulfilled, but the second condition is usually either not obtained or is approximately arrived at by an empirical adjustment of the resistances of the elements.

The following theory was developed primarily in order to arrive at a logical scheme of design for low pass filters, but it will be shown that it is possible to make use of the theory for band pass, band stop, and high pass filters.

The theory of the general filter-circuit of the Campbell type including resistance is not attempted, but it is shown how to obtain the best results from a two element filter and then how to combine any number of elementary pairs, separated from each other by valves, so as to approach closer and closer to the ideal filter as the number of stages are increased. In this way we can combine amplification and filtering properties in one unit, a combination that is often required in the applications of filter circuits.

This procedure also frees us from the necessity of considering the impedances of the circuits with which the filter is to be associated so that the filter amplifier may be used for a variety of circuits provided suitable input and output transformers are employed.

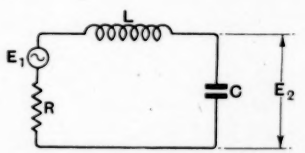


Fig. 1.

Further, in the Campbell filters, the elements (except the first and last) are similar, but in the present design we have assumed at first that we have perfect freedom in regard to the electrical constants of the elements and then these have been chosen with a view to obtaining the nearest approximation to the condition of uniform sensitivity in the "pass" region, and zero sensitivity in the "stop" region.

* The author is indebted to the Admiralty for permission to publish this paper.

MS. received by the Editor, May, 1930.

In the case of the low pass filter, if f_0 is the "cut off" frequency and f (xf_0) is any other frequency, the aim is to obtain a filter factor F, that is, the ratio of the output e.m.f. to the input e.m.f., of the form

$$F = (1 + x^m)^{-\frac{1}{2}} \quad .. \quad .. \quad .. \quad (1),$$

where m increases with the number of elements employed. It is clear that as m increases,

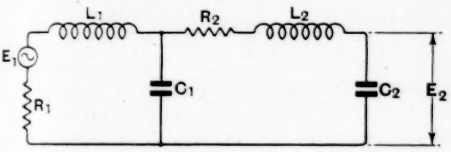


Fig. 2.

F will approximate more and more closely to the value unity when x is less than unity, and to zero when x is greater than unity.

For the case of a one element filter (Fig. 1), it is shown that by making $1/2\pi\sqrt{LC}$ equal to the cut off frequency and $L/C = \frac{1}{2}R^2$ we obtain a filter factor

$$F = (1 + x^4)^{-\frac{1}{2}} \quad .. \quad .. \quad .. \quad (2).$$

If this element follows a valve of known impedance, R is fixed, so that L/C is fixed. The value of LC follows from the required cut off frequency so that the numerical design is completely fixed.

For the case of a two element filter (Fig. 2) a filter factor

$$F = (1 + x^8)^{-\frac{1}{2}} \quad .. \quad .. \quad .. \quad (3)$$

may be obtained by satisfying four equations involving the seven quantities f_0, R_1, L_1, C_1, R_2, L_2, C_2.

For a given cut off frequency (f_0) and input resistance (R_1) we have thus four equations for five unknowns so that we are left with one further choice. It is convenient to choose a practically realisable value for $R_2/2\pi f_0 L_2$ and then the values of all the electrical constants follow.

For a series of two element filters interposed between valves we make use of the equation (*see* Todhunter's Trigonometry, p. 307)

$$1 + y^{2m} = (1 + 2y \cos \pi/2m + y^2)(1 + 2y \cos 3\pi/2m + y^2) \ldots (1 + 2y \cos (2m-1)\pi/2m + y^2)$$

Thus if we employ n intervalve elements and design the sth member so as to have a filter factor

$$F_s = (1 + 2x^4 \cos \theta + x^8)^{-\frac{1}{2}} \quad .. \quad (4)$$

in which $\theta = \cos(2s - 1)\pi/2n$

then from the above equation the whole filter factor will be

$$F = (1 + x^{8n})^{-\frac{1}{2}} \quad .. \quad .. \quad .. \quad (5).$$

The characteristics to be expected on this scheme are shown by the curves of Fig. 3. Curve A refers to a single element and curve B to a pair of elements, while curves C, D and E are for two three and six pairs respectively, each pair being an intervalve element. By adding the usual resistance capacity combination between the filter element and the grid as in Fig. 5, we thus obtain a filter amplifier having practically uniform pass sensitivity.

2. Low Pass Filter. One Element. Fig. 1.

A source of e.m.f. is applied to a circuit of inductance L, resistance R and capacity C. This, of course, is the ordinary resonating circuit and if the applied e.m.f. (E_1) has

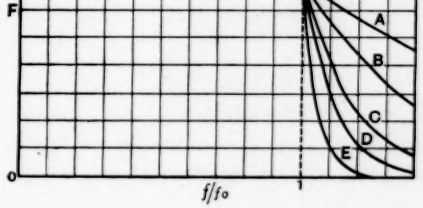


Fig. 3.

pulsatance ω, the output e.m.f. (E_2) is such that

$$(E_1/E_2)^2 = R^2\omega^2C^2 + (1 - \omega^2LC)^2 = 1 + \omega^2(R^2C^2 - 2LC) + \omega^4L^2C^2 \quad .. \quad (6).$$

Let $LC = 1/\omega_0^2$ and make $R^2 = 2L/C$ (7).

Then if $\omega/\omega_0 = x$, $(E_1/E_2)^2 = 1 + x^4$

the filter factor

$$F = (1 + x^4)^{-\frac{1}{2}} \quad .. \quad .. \quad .. \quad (8)$$

when condition (7) is satisfied.

3. Low Pass Filter. Pair of Elements. Fig. 2.

Generalise the circuit as in Fig. 4 for the purpose of carrying out the necessary algebra.

Z_1, Z_2, z_1, z_2 are the vector impedances of the various arms and on applying Ohm's Law we have

$$E_1/E_2 = (1 + Z_1/z_1)(1 + Z_2/z_2) + Z_1/z_2 \quad (9)$$

where E_1 and E_2 have now vector values.

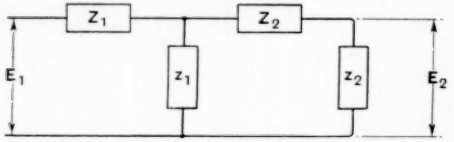


Fig. 4.

Let

$$L_1C_1 = 1/\omega_1^2,\ L_2C_2 = 1/\omega_2^2,$$
$$R_1/\omega_1L_1 = P_1,\ R_2/\omega_2L_2 = P_2 \quad .. \ (10).$$

Then since

$$\left.\begin{aligned} Z_1 &= R_1 + j\omega L_1,\ z_1 = 1/j\omega C_1 \\ Z_2 &= R_2 + j\omega L_2,\ z_2 = 1/j\omega C_2 \end{aligned}\right\} \quad .. \ (11)$$

we have

$$\left.\begin{aligned} 1 + Z_1/z_1 &= 1 - \omega^2/\omega_1^2 + jP_1\omega/\omega_1 \\ 1 + Z_2/z_2 &= 1 - \omega^2/\omega_2^2 + jP_2\omega/\omega_2 \end{aligned}\right\} \quad (12).$$

Also put

$$\omega/\omega_1 = x/a,\ \omega/\omega_2 = ax,\ C_2/C_1 = \beta \quad .. \ (13)$$

so that

$$x^2 = \omega^2/\omega_1\omega_2,\ a^2 = \omega_1/\omega_2 \quad .. \quad .. \ (14).$$

Then on substitution in (9)

$$E_1/E_2 = (1 - x^2/a^2 + jP_1x/a)$$
$$(1 - a^2x^2 + jP_1ax) + \beta(-x^2/a^2 + jP_1x/a) \quad .. \ (15).$$

Separate real and imaginary parts, square and add, and we obtain

$$1/F^2 = 1 + (B^2 - 2A)x^2 + (2 + A^2 - 2BC)$$
$$x^4 + (C^2 - 2A)x^6 + x^8 \quad .. \quad .. \ (16)$$

in which

$$\left.\begin{aligned} A &= (1 + \beta)/a^2 + a^2 + P_1P_2 \\ B &= P_1(1 + \beta)/a + P_2a \\ C &= P_1a + P_2/a \end{aligned}\right\} \quad .. \ (17).$$

If we can so choose the circuit constants that the coefficients of x^2, x^4, x^6 vanish then the filter factor will become

$$F = (1 + x^8)^{-\frac{1}{2}} \quad .. \quad .. \quad .. \ (18).$$

The conditions that these coefficients vanish are

$$B^2 = C^2 = 2A,\ 2 + A^2 = 2BC \quad .. \ (19).$$

On eliminating B and C we have

$$A^2 - 4A + 2 = 0 \quad .. \quad .. \ (20)$$

that is $A = 2 \pm \sqrt{2}$.

But examination of (17) shows that A must be greater than 2 so that the only realisable root is

$$A = 2 + \sqrt{2} = 3.414 \quad .. \ (21)$$

and then $B = C = 2.613$ .. (22).

Using these in (17) we have three equations to find a, β, P_1, P_2. One of these may be fixed arbitrarily. It is convenient to fix P_2/a, that is, by (14) $R_2/\sqrt{\omega_1\omega_2}L_2$, and since also by (14) $\sqrt{\omega_1\omega_2}$ is the cut of pulsatance (ω_0 say) we choose R_2/ω_0L_2 arbitrarily.

Then (17) fixes a, β, P_1, P_2. But a^2 is the ratio ω_1/ω_2 and $\omega_1\omega_2$ is fixed by the required cut off pulsatance, so that ω_1, ω_2 are fixed. The design is now completely fixed when the input resistance R_1 is specified, for P_1 determines L_1, then ω_1 determines C_1, β determines C_2, ω_2 determines L_2 and P_2 determines R_2.

4. Calculation of P_1, P_2, a, β.

The solution of equations (17) is facilitated by making use of the following substitutions.

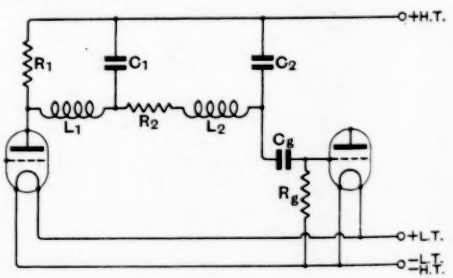


Fig. 5.

Put

$$a^2 - (1 + \beta)/a^2 = v,\ a^2 + (1 + \beta)/a^2 = 2 + kv \quad .. \quad .. \ (24)$$

so that

$$a^2 - 1 = \tfrac{1}{2}(1 + k)v,\ 1 - (1 + \beta)/a^2 = \tfrac{1}{2}(1 - k)v \quad .. \ (25).$$

Then, solving the last two of equations (17)

for P_1 and P_2 and putting $B = C = \sqrt{2A}$ we find with the help of (25)

$$P_1a = (1 + k)\sqrt{A/2},\ P_2/a = (1 - k)\sqrt{A/2} \quad .. \quad (26).$$

Using these in the first of equations (17) we obtain

$$2 + kv = (1 + k^2)A/2 \quad .. \quad .. \quad (27).$$

The numerical calculations can now be carried out thus :—

P_2/a is fixed arbitrarily, then, using the value of A in (21), k follows from (26). P_1a follows then from (26).

The value of v is next found from (27) and then a^2 and β are obtained from (25).

5. Design Tables.

The designer is given the values of R_1 and the cut off pulsatance ω_0 and requires the correct values of L_1, L_2, C_1, C_2 and R_2.

TABLE I.

SINGLE INTERVALVE ELEMENT. FIGS. 2, 6, 7 and 8.

$R_2/\omega_0 L_2$.	X_1.	X_2.	Y_1.	Y_2.	R_2/R_1.
0.00	0.3827	1.584	0.9277	0.6560	0.0000
0.05	0.3902	1.664	0.9019	0.7201	0.0823
0.10	0.3979	1.761	0.8798	0.7966	0.1761
0.15	0.4060	1.869	0.8577	0.8846	0.2803
0.20	0.4144	1.990	0.8353	0.9873	0.3980
0.25	0.4232	2.128	0.8128	1.108	0.5320

For this purpose it is convenient to construct Tables giving

$$X_1 = \omega_0 L_1/R_1,\ X_2 = \omega_0 L_2/R_1,$$

and R_2/R_1

$$Y_1 = 1/\omega_0 C_1 R_1,\ Y_2 = 1/\omega_0 C_2 R_1.$$

These quantities can be calculated as follows when P_1a, P_2/a a and β are known.

$$X_1 = 1/P_1a$$

$$X_1/Y_1 = \omega_0^2 L_1 C_1 = \omega_1^2 L_1 C_1 + \omega_2/\omega_1 = 1/a^2$$

$$Y_1/Y_2 = C_2/C_1 = \beta$$

$$X_2/Y_2 = \omega_0^2 L_2 C_2 = \omega_2^2 L_2 C_2 + \omega_1/\omega_2 = a^2$$

$$R_2/R_1 = X_2 P_2/a$$

giving in turn the quantities required.

Table I is the Design Table for a single pair of elements the values of $R_2/\omega_0 L_2$ in the first column being assumed.

6. Multistage Filter Amplifiers. Fig. 5.

In a filter amplifier having n intervalve stages the filter for the sth stage must be designed so that

$$A^2 - 4A + 2 = 2\cos(2s - 1)\pi/2n \quad .. \quad (28)$$

{see equations (4) and (16)} while

$$B^2 = C^2 = 2A \quad .. \quad .. \quad .. \quad (29).$$

as before.

The solution of (28) is

$$A = 4\cos^2(2s - 1)\pi/8n \quad .. \quad .. \quad (30)$$

so that the design is exactly as in section (4) except that we use (30) for A instead of (21).

TABLE II.

TWO INTERVALVE STAGES.

$R_2/\omega_0 I_2$.	X_1.	X_2.	Y_1.	Y_2.	R_2/R_1.	Stage.
0.00	0.3605	1.582	1.027	0.5556	0.000	1
	0.4252	1.749	0.7507	0.9808	0.000	2
0.05	0.3671	1.669	1.007	0.6082	0.0834	1
	0.4345	1.879	0.7233	1.129	0.0940	2
0.10	0.3740	1.762	0.9877	0.6672	0.1762	1
	0.4441	2.069	0.6951	1.322	0.2069	2
0.15	0.3811	1.869	0.9688	0.7350	0.2803	1
	0.4540	2.318	0.6670	1.578	0.3478	2
0.20	0.3885	1.984	0.9450	0.8115	0.3968	1
	0.4647	2.704	0.6364	1.974	0.5407	2
0.25	0.3962	2.113	0.9312	0.8988	0.5281	1
	0.4758	3.333	0.6054	2.620	0.8332	2

Tables II and III are the Design Tables for two stage and three stage systems respectively while Table IV holds for four, five and six stage systems.

Fig. 5 shows the nature of the intervalve system, R_g and C_g being the usual resistance capacity elements.

7. Band Pass Filters. Fig. 6.

Starting with a low pass filter system suppose we put in series with L_1, L_2 the capacities C'_1, C'_2 and in parallel with the capacities C_1, C_2 the inductances L'_1, L'_2.

TABLE III.

THREE INTERVALVE STAGES.

Stage 2 as in Table I.

$R_2/\omega_0 I_2$.	X_1.	X_2.	Y_1.	Y_2.	R_2/R_1.	Stage.
0.00	0.3566	1.587	1.046	0.5412	0.0000	1
	0.4456	1.983	0.6763	1.307	0.0000	3
0.05	0.3631	1.674	1.026	0.5921	0.0837	1
	0.4558	2.267	0.6461	1.599	0.1133	3
0.10	0.3698	1.770	1.008	0.6497	0.1770	1
	0.4664	2.715	0.6148	2.059	0.2715	3
0.15	0.3768	1.876	0.9889	0.7147	0.2814	1
	0.4776	3.548	0.5823	2.910	0.5322	3
0.20	0.3840	1.995	0.9706	0.7884	0.3985	1
	0.4893	5.720	0.5483	5.104	1.144	3
0.25	0.3915	2.123	0.9524	0.8725	0.5307	1
	0.5015	27.43	0.5125	26.84	6.858	3

Let these new capacities and inductances be such that

$$L_1C'_1 = L_2C'_2 = L'_1C_1 = L'_2C_2 = 1/\omega_a^2 \quad (31).$$

Then the generalised circuit (Fig. 4) will have for its vector impedances

$$Z_1 = R_1 + j\zeta L_1,\ z_1 = 1/j\zeta C_1,$$
$$Z_2 = R_2 + j\zeta L_2,\ z_2 = 1/j\zeta C_2 \quad \ldots (32)$$

in which $\zeta = \omega - \omega^2_a/\omega$.

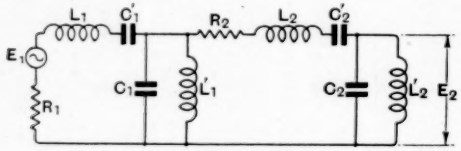


Fig. 6.

Now (32) is of the form (11) so that the whole of the low pass filter theory will hold. The interpretation of x however is now

$$x = \zeta/\sqrt{\omega_1\omega_2} = (\omega - \omega^2_a/\omega)/\sqrt{\omega_1\omega_2} \quad (33).$$

The form of the filter factor shows that the cut off pulsatances are such as to satisfy $x = \pm 1$ or

$$\omega - \omega^2_a/\omega = \pm\sqrt{\omega_1\omega_2} \quad \ldots \quad \ldots (34).$$

TABLE IV.

FOUR INTERVALVE STAGES.

R_2/ω_0L_2.	X_1.	X_2.	Y_1.	Y_2.	R_2/R_1.	Stage.
0.00	0.3553	1.588	1.052	0.5364	—	1
	0.3695	1.576	0.9838	0.5916	—	2
	0.4009	1.608	0.8463	0.7617	—	3
	0.4574	2.265	0.6358	1.630	—	4
0.05	0.3617	1.676	1.033	0.5868	0.0838	1
	0.3764	1.661	0.9635	0.6490	0.0831	2
	0.4091	1.706	0.8221	0.8491	0.0853	3
	0.4681	2.769	0.6039	2.146	0.1384	4

FIVE INTERVALVE STAGES.

R_2/ω_0L_2.	X_1.	X_2.	Y_1.	Y_2.	R_2/R_1.	Stage.
0.00	0.3546	1.589	1.055	0.5342	—	1
	0·3636	1.579	1.012	0.5676	—	2
	0.4147	1.662	0.7912	0.8713	—	4
	0.4650	2.562	0.6104	1.951	—	5
0.05	0.3610	1.677	1.036	0.5843	0.0839	1
	0.3703	1.665	0.9917	0.6219	0.0833	2
	0.4234	1.782	0.7652	0.9859	0.0891	4
	0.4760	3.387	0.5773	2.793	0.1694	5

For Stage 3, see Table I.

SIX INTERVALVE STAGES.

R_2/ω_0L_2.	X_1.	X_2.	Y_1.	Y_2.	R_2/R_1.	Stage.
0.00	0.3543	1.590	1.057	0.5330	—	1
	0.3734	1.574	0.9058	0.6087	—	3
	0.3942	1.592	0.8742	0.7180	—	4
	0.4702	2.865	0.5930	2.272	—	6
0.05	0.3607	1.678	1.038	0.5830	0.0839	1
	0.3805	1.660	0.9449	0.6685	0.0830	3
	0.4021	1.685	0.8508	0.7965	0.0843	4
	0.4816	4.146	0.5592	3.571	0.2073	6

For Stages 2 and 5, see Table II.

Putting $\sqrt{\omega_1\omega_2} = \omega_0$ as before we have now two cut off pulsatances (ω_α, ω_β) given by

$$\omega_\alpha = \tfrac{1}{2}\omega_0 + \sqrt{\omega^2_a + \tfrac{1}{4}\omega_0{}^2}$$
$$\omega_\beta = -\tfrac{1}{2}\omega_0 + \sqrt{\omega^2_a + \tfrac{1}{4}\omega_0{}^2} \quad \ldots (35)$$

(33) shows that if $\omega_\alpha > \omega > \omega_\beta$, x is less than unity so that the filter is now a band pass filter having cut off pulsatances given by (35). The width of the band is $\omega_\alpha - \omega_\beta = \omega_0$ and the centre of the band is

$$\omega_r = \tfrac{1}{2}(\omega_\alpha + \omega_\beta) = \sqrt{\omega^2_a + \tfrac{1}{4}\omega_0{}^2} \quad \ldots (36).$$

Hence for a given centre ω_r and given band width ω_0 we use the low pass filter Tables to calculate the circuit constants together with equations (31) and (36).

It is interesting to notice that for a given band width the values of L_1, L_2, C_1, C_2 and R_2 are fixed and adjustment of L'_1, L'_2, C'_1 and C'_2 simultaneously shifts the band bodily along the frequency scale.

8. High Pass Filters. Fig. 6.

In the low pass system let the inductances be replaced by capacities and the capacities by inductances. Since $j\omega L$ becomes $1/j\omega C$ and *vice versa*, terms such as ω^2LC are replaced by $1/\omega^2LC$ that is, if $LC = 1/\omega_1{}^2$ we replace ω/ω_1 by ω_1/ω. Hence x is now interpreted as ω_0/ω and the pass region is for pulsatances *greater* than ω_0.

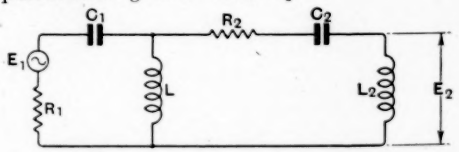


Fig. 7.

In the Design Tables we now interpret X_1, X_2, Y_1, Y_2 as follows :—

$$X_1 = 1/\omega_0C_1R_1,\ X_2 = 1/\omega_0C_2R_1$$
$$Y_1 = \omega_0L_1/R_1,\ Y_2 = \omega_0L_2/R_1 \quad \ldots (37)$$

9. Band Stop Filters. Fig. 8.

These are obtained from high pass filters by putting inductances L'_1, L'_2 in parallel with the capacities C_1, C_2 and capacities C'_1, C'_2 in series with the inductances L_1, L_2. The values of the new capacities and inductances are obtained from

$$L'_1, C_1 = L'_2C_2 = L_1C'_1 = L_2C'_2 = 1/\omega^2_a \quad \ldots (38).$$

in which $\omega^2_a = \omega^2_r - \frac{1}{4}\omega_0^2$

ω_r = mid point of stop region.
ω_0 = width of stopped band.

DESIGN TABLES.

A. Method of use for Low Pass Filters. Fig. 2.

The given quantities are the cut off pulsatance and the input resistance R_1

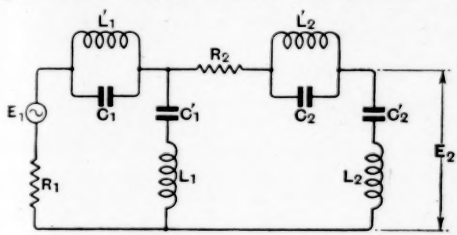


Fig. 8.

(fixed by the valve employed and its associated anode resistance).

Assume a value for $R_2/\omega_0 L_2$ and then read off X_1, X_2, Y_1, Y_2 from the appropriate Table.

Then

$L_1 = X_1 R_1/\omega_0$, $L_2 = X_2 R_1/\omega_0$, $C_1 = 1/Y_1\omega_0 R_1$, $C_1 = 1/Y_2\omega_0 R_1$

If R_1 is in ohms, then the calculated values of L_1, L_2 are in henrys and those of C_1, C_2 are in farads.

B. Use for Band Pass Filters. Fig. 6.

ω_0 is now the band width and L_1, L_2, C_1, C_2 are calculated as above. L'_1, L'_2, C'_1, C'_2 are calculated from

$$L'_1 C_1 = L'_2 C_2 = L_1 C'_1 = L_2 C'_2 = 1/\omega^2_a$$

in which $\omega^2_a = \omega^2_r - \frac{1}{4}\omega_0^2$

and ω_r is the mid point of the band.

C. Use for High Pass Filters. Fig. 7.

ω_0 is the cut off pulsatance and

$C_1 = 1/X_1\omega_0 R_1$, $C_2 = 1/X_2\omega_0 R_1$, $L_1 = R_1 Y_1/\omega_0$, $L_2 = R_1 Y_2/\omega_0$

the units being as before.

D. Use for Band Stop Filters. Fig. 8.

ω_0 is the band width and ω_r the mid point of the band. Calculate L_1, L_2, C_1, C_2 as in (C) and then L'_1, L'_2, C'_1, C'_2 as in (B).

Book Review.

A First Electrical Theory for Schools. By H. W. Heckstall-Smith.

Although there has been a prolific output of books on elementary electricity and magnetism during recent years, there have been very few departures from the old and stereotyped method of treatment. The great majority of such books fail in their purpose for two main reasons: first because they are written in a style which is too heavy and ponderous to maintain the keen interest of young readers just embarking on a new subject, and secondly because, although an introduction is devoted to electrons and the electron theory, subsequent chapters revert to the old and time-worn arguments which the electron theory has replaced. In many instances no further reference is made to the electron theory after the first chapter.

In "A First Electrical Theory for Schools," however, the author has carefully avoided all such pitfalls, and is to be congratulated on producing a book of outstanding merit. He has not only realised the vital importance of instilling the correct ideas into the minds of his young readers right at the outset, but, what is equally important, he encourages the reader to reason for himself and not to rely on parrot-like memory.

The explanations of the various laws are given in a delightfully simple manner and in a way that is calculated to give the beginner the feeling that he is credited with the ability to think for himself. This, together with the numerous analogues given, will do more than anything else to arouse and maintain keen interest on the part of the student. The touch of humour in some of the analogues will assist in this direction.

With but 300 pages of subject matter the scope of the book is remarkable, and yet nothing of importance seems to have been omitted. One reason is that space has not been wasted in describing and illustrating obsolete types of instruments. Numerous worked examples are given throughout and complete instructions are given at the end of each chapter for experimental work. Theoretical questions are also given throughout with answers at the end of the book.

It is perhaps not a very serious matter that the international system of symbols is not fully adhered to, but at the same time it seems rather strange that having chosen I to represent current, V should be chosen for E.M.F. and potential difference. It would seem more reasonable to choose either both of the international symbols E and I or else V and A (for volts and amps.).

The question of sequence always presents a certain amount of difficulty, but the author has resorted to the happy expedient of devoting the first three chapters to the simplest ideas and laws of Elementary Electrostatics, Elementary Magnetism and Elementary Electromagnetism in the order mentioned, returning at a later stage in the book to the deeper aspects of each branch. By this means students are brought to realise to the fullest extent the inter-relationships between the various branches.

This excellent little book is published by Dent & Sons, Ltd., and sells at 4s.—S.O.P.

Practical Experiments in Ultra-short Wave Communication.*

By C. C. Whitehead.

AS the result of the experiments to be described, the writer has formed the opinion that when the technique of their use and application has been mastered to the same extent as that of longer waves, ultra-short waves will occupy a special and extremely useful niche of their own in the field of radio-communication.

The definition of " ultra-short " waves is probably not yet standardised, but if we are to classify them according to what is so far known about their behaviour in regard to propagation (the only logical method of classification, from the radio engineer's point of view), we can conveniently term waves less than 6 metres in length " ultra-short."

Under the above system of classification, the normal " short-wave " band of waves used for long-distance communication seems to have its lower wavelength limit somewhere just below 9 metres. As yet, this limit does not seem to have been accurately defined.

The present experiments were carried out upon a wavelength (or rather, a narrow band of wavelengths) well within the " ultra-short-wave " region, *i.e.*, just below 3 metres. Their object was to determine whether these waves could be used with any reasonable amount of success for communication at ground level, as in normal wireless telegraphy. (Up to the time of writing, no notable success has been attained in this direction, though communication by means of these waves has been quite successful under special conditions.)† With this object in view, the first task was the design of a simple, stable, and practical outfit for the generation and reception of these waves. This is dealt with in the first two sections of the article.

The whole of the work is set out under the following headings :—

Section (A). Experimental Design and Construction of Transmitter.

Section (B). Experimental Design and Construction of Receiver.

Section (C). Range Tests, and experiments upon Propagation.

Section (D). Conclusion.

Appendix.

(A). The Transmitter.

The experimental design of the transmitting portion of the apparatus was undertaken first. No definite wavelength band was decided upon in advance, though it was decided to limit the input power to 50 Watts, as this was judged to be sufficient for the purpose. During the actual range tests, however, less than half this amount of input power to the transmitter proved amply sufficient for the work in hand.

The first difficulty experienced was one in connection with the valves themselves, entirely apart from the circuit arrangement used, and one, moreover, which seemed to be present to a greater or less extent in the case of every valve tried. This was the upper frequency (or lower wavelength) limit at which the valve could be made to give a reasonable output. This was not the limit set by the structural design of the valve. As the working frequency was increased, there came a point (long before the smallest possible circuit dimensions had been reached) where the output from the valve suddenly decreased, and fell to zero, or nearly so. This usually occurred at frequencies corresponding to wavelengths between 4 and 5 metres.

The cause of this trouble was only deduced after the remedy had been accidentally found.

If we set the oscillator frequency above this critical point, the output is zero, *i.e.*, the valve is not oscillating. Upon placing the hand, or other conductor or semi-conductor, in *close* contact with the outside of the valve envelope, the original value of the output (or nearly so) is restored, even though the frequency is perhaps twice the critical value.

In practice, this difficulty was overcome by covering about 60 per cent. of the surface

* MS. received by Editor, August, 1929.

† *See* Appendix, A (1)–(5) (*in next month's issue*).

of the valve envelope with tinfoil, pasted on with shellac varnish, or seccotine. Nearly the whole of the surface (except for a margin of about $\frac{1}{2}$in. just below the anode cap), can be covered in this way, but this is not necessary or advisable, since it hinders the dissipation of heat from the valve.

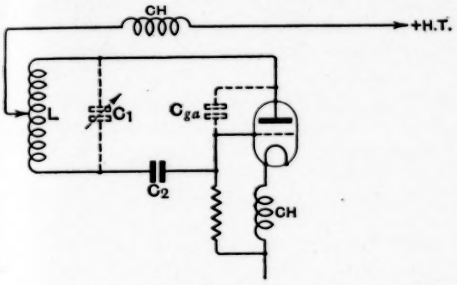


Fig. 1.

It did not seem to matter what part of the envelope was covered in this way, so long as the covering was there, *and in close contact with the glass.*

Whatever valve was tried, this expedient invariably had the effect of raising the frequency limit at which the valve could be made to work at reasonable efficiency.*

The second problem was the choice of the circuit to be used. Many well-known workers (Mesny, Esau, and Hollmann, and others) have strongly advocated the use of twin-valve circuits of the " push-pull " type. They have pointed out that the primary requisite, in ultra-short-wave work, is a circuit which is *electrically symmetrical*, and the use of a circuit of this type is a great aid in attaining this end, since, if we choose a pair of valves with (as near as possible) similar characteristics, and mechanical structure, arranging the associated circuit so as to be mechanically symmetrical, we automatically obtain electrical symmetry, to a close approximation.

Though this type of circuit was tried it was abandoned, finally, in favour of a single-valve circuit, of suitable design.

When we say " a single-valve circuit, of suitable design," we practically limit ourselves to one or the other of the two arrangements now to be discussed.

The first circuit tried was the popular one (at least, for short waves) shown in Fig. 1. This circuit is usually satisfactory (with standard valves) when we simply wish to work on a single frequency, and if the circuit capacity consists only of the grid-anode capacity of the valve, *i.e.*, if the capacity " C_1 " in Fig. 1 is omitted. The capacity " C_2 " is not important so long as it is much larger than " C_{ga}."

The trouble commences when we try to arrange a tuning control on our oscillator. In considering what follows, it must be borne in mind that in the normal type of valve, when used in this connection, the inductance of the internal connections to the valve electrodes forms a large part of the total inductance of the circuit when working at wavelengths of the order of those under consideration.

Thus, when we connect " C_1 " in Fig. 1, to work as a tuning control, whilst we fondly imagine that we are still using (*l*) the circuit shown in Fig. 1 (with " C_1 " added) we are in reality using one or the other of the circuits shown in Fig. 2 (*a*) or (*b*). Here " l_1 " and

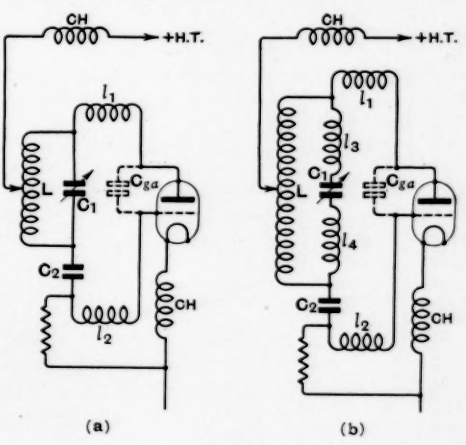


Fig. 2.

" l_2 " represent the inductances formed by the internal connections to the electrodes of the valve, and " l_3 " and " l_4 " the inductances formed by the leads used to connect " C_1 " (including the inductance of " C_1 " itself, which may be by no means negligible, at these frequencies). This arrangement leads to all sorts of troubles (including that of sudden change of frequency as " C_1 " is varied).

* This is discussed at length in the Appendix, B (1).

The only circuit which seemed to offer immunity from these troubles was the one shown in Fig. 3, and first used in practice by Gill.*

This circuit also had another and apparently exclusive merit, namely, that it

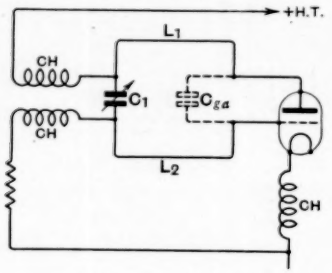


Fig. 3.

never failed to oscillate, provided only that "C_1" exceeded a certain critical value.

The use of the grid and anode chokes is not essential to the working of the fundamental circuit, but, since "C_1" is to be used as a tuning control, we insert the chokes so as to allow H.F. potentials to be developed across it, otherwise the shunting effect of the mutual capacity of the grid and anode current leads would render it ineffective in this direction.

A peculiar effect observed was that, though the circuit would oscillate quite readily when the grid and/or anode chokes were dispensed with, it could not be induced to work at all if the filament chokes were omitted. This was assumed to be due to an unavoidable electrical asymmetry of the circuit.† This did not cause any trouble in practical working, in fact, it was later turned to good account, sufficient H.F. voltage being available at this point to excite a tiny "absorption" type wavemeter with lamp indicator attached here.

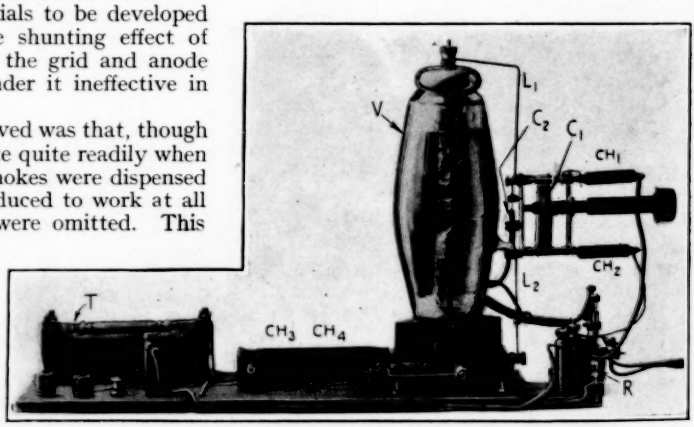
The next problem was the choice of a suitable valve to use with the circuit. A number of valves were tried and the most satisfactory type proved to be a Marconi-Osram D.E.T.1 S.W. This valve was used complete with its normal base and mounted as shown in detail in Fig. 11. For practical purposes this is essential, since we cannot go to the trouble of "decapping" a valve and building it into the apparatus every time a replacement is required.

This choice of valve proved to be a happy one, for the following reasons:—

(*a*) Its mechanical construction is eminently suitable, the internal leads to the electrodes being very stout, and suitable for carrying the comparatively heavy H.F. currents which they are called upon to carry when the valve is used in this manner, as they form an integral part of the oscillatory circuit.

(*b*) An approximate mathematical investigation, taking into account all known factors, showed that the working A.C. resistance of the valve and the effective impedance of the associated circuit were in the ratio 1 : 2, which is the optimum condition.‡

(*c*) Its comparatively low A.C. resistance (3,500Ω at $Va. = 400$, $Eg. = 0$) enables us to obtain the output required, without the use of an inconveniently high anode voltage.



General view of transmitter. The lettering corresponds with that on Fig. 4.

* The writer believes that this circuit has recently attained popularity in the U.S.A. under the name of the "Huxford oscillator."

† *See* Appendix, B (2).

‡ *See* Appendix, B (3).

The use of pure C.W. was not deemed practicable, at least for a commencement, so arrangements were made to modulate the output. As the simpler and least expensive method, grid circuit modulation was first tried and, proving very satisfactory, was retained. In the first series of tests, to be described in this article, a Morse key and buzzer were used in the primary circuit of the modulating transformer, these being replaced by a microphone, for telephony, the source of current being the D.C. L.T. supply (6 v.). As it was assumed that it would be more convenient to operate the transmitter from a distance (on account of the possible effect of the presence of the operator) four leads only were brought out (1, 2, 3 and 4, Fig. 4) from the oscillator baseboard. It was found advisable to use a small fixed condenser (C_2, Fig. 4) in parallel with the tuning capacity C_1 to "set up" the minimum to a point just above the critical value. When the circuit dimensions were finally fixed, the wavelength band covered by the apparatus was measured.

This measurement was carried out by the well-known Lecher-wire method, and the results obtained were :—

Range of wavelengths :—2.68—2.82 metres
= range of frequencies :—106.3 — 112 Megahertz
= Tuning range of 5,700 Kilohertz.

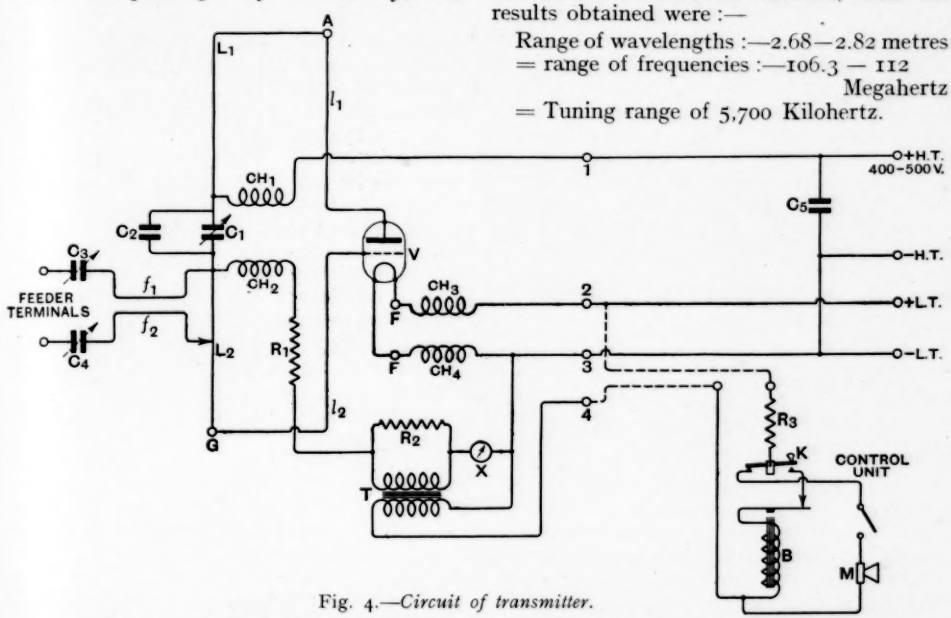


Fig. 4.—*Circuit of transmitter.*

A, G, F, F—terminals of valve socket. V—valve, Marconi-Osram D.E.T.1 S.W. (L.T., 6v. 2A.). l_1, l_2—portion of loop-circuit formed by internal structure of valve. L_1, L_2—anode and grid portions, respectively, of external part of inductance of loop-circuit. C_1—tuning condenser, variable, .0001μF. max. C_2—auxiliary fixed condenser, to "set up" the minimum capacity of C_1, .00003μF. C_3, C_4—feeder blocking condensers, .0001μF. each. C_5—H.T. "Reservoir" condenser; actual capacity depends upon source of H.T. supply; in the apparatus herein described, using a good H.T. D.C. generator (free from bad commutator "ripple"), .3μF., to work at 500v. D.C. Ch_1, Ch_2—anode and grid feed chokes, respectively. Ch_3, Ch_4—filament chokes; actually, one choke, with bifilar winding. R_1—grid leak, 6,000 Ω, total grid leak resistance = resistance of grid leak, plus resistance of microphone transformer secondary winding (3,000 Ω) = 9,000 Ω. R_2—Resistance in parallel with secondary winding of microphone transformer, 250,000 Ω (grid leak type). R_3—20-30 Ω. T—microphone transformer. K—Morse key. B—buzzer (Ericsson type used in present arrangement). M—microphone (carbon-granule "inset" type). f_1, f_2—feeder coupling leads. X—grid-current meter, 0-5μA.

This proved to be quite a convenient tuning range, in practice.

The sole remaining task now, as far as the transmitter was concerned, was to devise a convenient and reasonably efficient radiating system.

The most simple, convenient, and efficient aerial for the proposed experiments was the half-wave "dipole." This type of aerial was used exclusively during the experiments, both for transmitter and receiver. The method of coupling the aerial to the oscillator now claimed attention.

Direct inductive coupling to the oscillator (by proximity, Fig. 4(*a*)) was, of course,

successful from the electrical point of view, but as it was desired to change frequently the plane of polarisation of the emitted wave, this arrangement had serious drawbacks from the mechanical point of view, as rotation of the plane of polarisation would involve rotation of the whole of the oscillator and aerial assembly. Moreover, for the purpose of the range tests, it was desirable to have the aerial situated outdoors, whilst the oscillator should be under shelter and handy to the operator. This called for the use of a feeder system. The "dipole" was divided at the centre and fed by a pair of Lecher wires (Fig. 4(*d*)). At the aerial end of the feeder this proved to be the most efficient arrangement, but a little difficulty was experienced at the input (oscillator) end. An attempt to couple the feeder by means of a small coil was not successful (Fig. 4(*b*)), either the coupling could not be made close enough, or the adjustment was too critical; finally, the method shown in Fig. 4(*c*) was used, *i.e.*, direct inductive ("auto-transformer") coupling to the oscillator inductance. This proved very satisfactory and efficient. Referring again to Fig. 4 (the complete diagram of the oscillator assembly) it will be seen that as the feeder is coupled directly to the grid circuit inductance L_2, it is necessary to interpose the two small (adjustable) condensers C_3, C_4 in the leads to the feeder terminals, in order to isolate the feeder and aerial system from the grid modulating potential and D.C. bias (imposed during operation by the leak R_1). If adjustable, these condensers also serve to make small adjustments in the surge impedance of the feeder.

Provision was made for a "control unit," comprising Morse key, buzzer and microphone, to be situated at some distance from the oscillator. Though this precaution was adopted in the preliminary experiments, with direct antenna coupling, with the feeder system finally adopted, it proved to be unnecessary, the presence of the body of the operator in proximity to the oscillator seeming to have no noticeable effect.

An end-on view of the transmitter.

The feeder finally used consisted of a length of twin twisted 7/30 "Cabtyre" flex, 3.5 metres in length. (Its "electrical length" was therefore 1.5 wavelengths.) This enabled the aerial to be placed upon a wooden pole, outside the building, whilst the oscillator was accommodated upon the work-bench, indoors.

The aerial current was first of all measured in the usual manner, by means of a thermal ammeter placed at the junction of the feeder and antenna (when this was excited *via* the feeder). Once the satisfactory operation of the apparatus had been verified by this

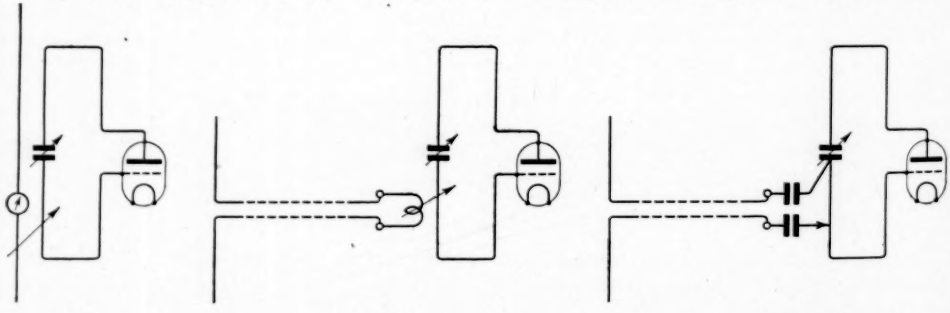


Fig. 4 (*a*), (*b*), (*c*).

means, the reading of the grid-current meter (*X*, in Fig. 4) was noted for various values of aerial current, at the given input. Subsequently, this was used as a check upon the satisfactory operation of the transmitter.

When the transmitter is in use, the valve is oscillating continuously, and during modulation the aerial current is increased by some 15 to 20 per cent. This method of operation gives very steady and clean-cut Morse signals. The speech quality is quite good.

The working test gave the following result :—

Input — 500 v. 60 ma. = 30 Watts.

Aerial current, aerial coupled direct (by proximity) to oscillator — .1875 a. ; aerial current, aerial coupled *via* feeder to oscillator — . 15 a., *during the " spacing " period.*

This indicates aerial powers of 3.13 and 2 Watts, respectively.

The actual " power conversion efficiency " of the oscillator is about 12 per cent., which seems rather low. The chief reason for this has been pointed out by Hollmann and others, namely, that the oscillation time-period is comparable with the time of transit of the electrons constituting the " space-current." In this particular instance, the

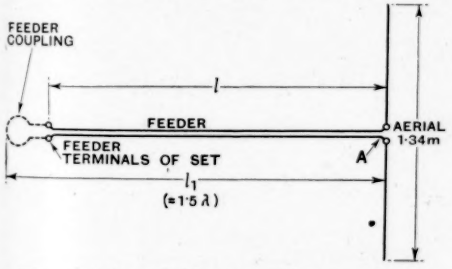


Fig. 4 (*d*).—*Detail of aerials and feeders. (Constructional details, Appendix C* (3)). A = *point of insertion of current meter (if used).*

loss due to this cause is estimated *at about 40 per cent. of the input energy.**

The feeder loss, also, is apparently high, about 35 per cent., mainly dielectric losses.

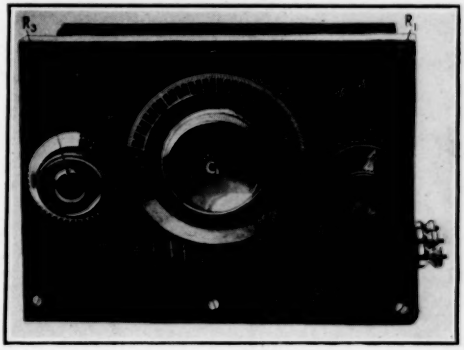
For the purpose of checking the results given in Section D, the transmitter has recently been adapted for automatic operation, from a P.O. Wheatstone transmitter. This is discussed under that section.

* *See* Appendix, B (4). Read also Hollmann and Englund, Appendix, A (4), A (6).

(B). The Receiver.

It is in the design of a suitable receiving apparatus for these very short waves that the greatest scope for technical improvement seems to exist.

Out of the region of the direct field, the attenuation of these waves is apparently so rapid that, if they are to be successfully used for communication *at or near ground level*, an



Front view of receiver. The lettering corresponds with that on Fig. 5.

entirely new technique in receiver design is likely to be required.

At long ranges, or under difficult conditions, the field strength at the receiver is extremely small, and variable according to local conditions. This calls, primarily, for an extremely sensitive and efficient detector, as at these frequencies pre-detector " boosting " of the received energy is, at the present stage of development, out of the question.

The only solution or partial solution of the problem at the moment is the use of " super-regeneration."

The receiver used finally, consisted then of a detector circuit, arranged for operation with or without super-regeneration, followed by a conventional two-stage L.F. amplifier.

Before commencing work upon the receiver, it was decided that a " low-capacity " (V.24) type of valve would be essential as the detector and no attempt was made to use any other type. Having found the " Gill " circuit a sure oscillator, in connection with the design of the transmitter, it was decided to use this circuit (or a modification of it) in the design of the receiver. This

proved successful from the first, and the final form of the receiver (less the L.F. portion, which is not described, since it follows normal practice) is shown in Fig. 5. The signal-frequency portion of the apparatus shown in the figure is that part contained within the dotted lines representing the screen.

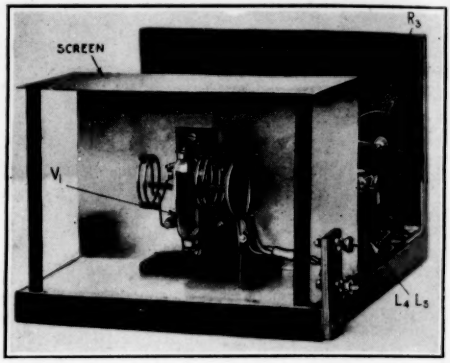
It is, as remarked earlier, the circuit of Fig. 3, with the following modifications :—

(1) C_1 is of fixed value.

(2) The tuning control, in this case, consists of a small variable capacity (maximum capacity, approximately 1.5 cms.) in parallel with C_{ga}. (The use of a paralleled tuning capacity is quite justified in this case, notwithstanding the remarks made in Section (A), *because the valve used here has such short internal leads (about $\frac{1}{4}$in.) that the above remarks do not apply.*)

(3) A certain amount of magnetic coupling is introduced between L_1 and L_2. (The mutual inductance is negative in sign.)

The correct size of the coils L_1 and L_2 was determined by practical experiment, after preliminary calculation made to determine their approximate dimensions. They were made just a trifle larger than the estimated



Rear view of receiver. The lettering corresponds with that on Fig. 5.

value, and " cut down " until the tuning band of the transmitter occupied the centre of the receiver tuning scale (over an arc of about 60°).

C_1 was built into the valve-holder. (The reason for this construction will be obvious from (2), above.)

No attempt was made, at first, to embody a reaction control, and the writer was much surprised to discover that control of the filament-temperature performed this function most efficiently. (This was all the more surprising since anyone who has tried this method of reaction control on receivers designed for longer waves, will know how very unsatisfactory it is.) However, though other methods of reaction control were tried, the writer returned finally to this method. Its outstanding merit was, that it caused no appreciable frequency change during adjustment (within normal working limits), a disadvantage found to be present, to a large extent, with other methods. It also has the obvious merit of simplicity.

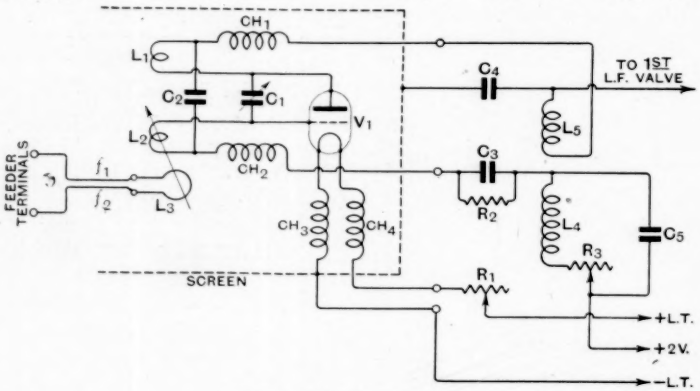


Fig. 5.—*Circuit of receiver.*

L_1, L_2—anode and grid portions, respectively, of circuit inductance. L_3—feeder coupling inductance. f_1, f_2—feeder coupling leads. Ch_1, Ch_2—anode and grid chokes, respectively. Ch_3, Ch_4—filament chokes (same remarks apply as to transmitter filament chokes, see constructional details). C_1—tuning condenser; capacity = 1.3 cm. max. (approx.), see constructonal details. C_2—blocking condenser, .0001μF. (special condensers). C_3—grid condenser, .001μF. (normal pattern). R_1—filament rheostat, 5 Ω max. R_2—grid leak, 3 megohms. *Quenching Circuit :* L_4—quenching circuit inductance, 75,000μH. L_5—quenching circuit reaction winding, 2,000μH. approx. C_5—quenching circuit tuning condenser (fixed), .0003μF. C_4—quenching circuit blocking condenser (fixed), .002μF. R_3—quenching circuit reaction control, 400 Ω max. V_1—detector valve, Marconi-Osram V24 (or D.E.V.) (L.T., 4V.). The L.F. amplifier is not described, as this follows standard practice.

The receiver, as above described, was used in the earlier experiments with a half-wave " dipole " aerial directly coupled, as at first tried in the case of the transmitter. The ranges obtained with this arrangement, however, were very disappointing, so it was decided to couple the receiving aerial, also, by means of a " feeder," and to employ " super-regeneration " to give greater sensitivity.

The type of quenching circuit shown (that portion of Fig. 5 which has not already been described) was adopted as this had been found a success when used in connection with receivers designed to work upon the normal short wavelength band. The only difficulty when first tried was to control efficiently the amplitude of the quenching E.M.F. (R_3 was not included, at this time), as this is rather critical when dealing with weak signals.

If the quench is not strong enough, weak signals are not sufficiently amplified, and if it is too strong, the signals are " drowned " by the enormous amount of " mush " that is brought in. " Mush " is probably an inaccurate description of this noise, 90 per cent. of which undoubtedly originates within the circuit itself. For this reason the writer is of the opinion that the amount of this noise heard, when the receiver is in operation, is no criterion whatever of its sensitivity, and seems to depend to a large extent (other things being equal) upon the method of rectification used.

The quenching frequency is not critical, any frequency between 10 and 100 kc. being satisfactory. It is preferable to use a frequency well above audibility (about 30 kc.), for the following reasons :—

(1) The quench coils, etc., can be smaller in dimensions.

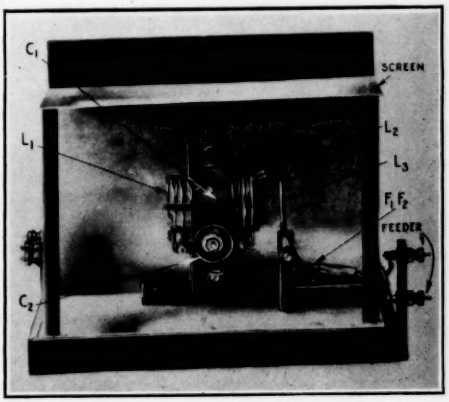
(2) Separation of quenching and audio-frequencies is easier. But chiefly :—

(3) The use of a quenching frequency just upon the verge of audibility (8–12 kc., according to the individual human ear) has been found, in many cases, to produce a very unpleasant kind of mental strain or fatigue, when the receiver is in use for more than a few minutes at a time. (Regarding this as somewhat analogous to " eye-strain," one might term it, " ear-strain.") Whether all operators are affected in this manner the writer cannot say, but every operator of his acquaintance, who has had the experience of long " watches " on a super-regenerative receiver has observed this effect, which is very peculiar and hard to describe. One experiences a great feeling of relief when the quench is switched off, and the receiver used as a " straight."

This latter effect is not produced when the quenching frequency is well above audibility, as in the case of the receiver described.

The increase in range obtained by the use of super-regeneration was remarkable. With the " straight " receiver, the signals were never readable at a greater distance than 500 yds., under the conditions obtaining during the range tests, even when the improved aerial coupling arrangement, with feeder, was used.

The aerial and feeder used is identical with that described in connection with the transmitter. (A reference to the photographic illustrations will prove more helpful in explaining the constructional arrangements than any amount of written description.)



Rear view of receiver with valve removed. The lettering corresponds with that on Fig. 5.

It was found essential to screen partially the signal-frequency portion of the receiver, and the screen shown was very effective, no trace of frequency-shift due to movements of the operator being noticeable during operation.

The use of metal foil in contact with the envelope of the detector valve was not

necessary, nor did it seem to make any difference when it was used.*

Observations upon the sharpness of tuning of the receiving circuits were interesting. When the valve was not oscillating, the tuning was extremely flat, the signals being heard over the whole of the tuning scale. As reaction was applied, the tuning became sharper, until, with reaction adjusted to the optimum value, it was found difficult to tune in the signal, even when close to the transmitter! This applies to the "straight" receiver only. The effect of bringing the "quench" into operation was to flatten the tuning once more, to the extent that the signal was audible over about 5° of the tuning scale, when Morse (I.C.W.) signals were being received. As previously remarked, the use of the receiver as a "straight" was soon abandoned, in view of the much greater efficiency of the super-regenerative arrangement. The quench can, of course, be put into or out of operation, at will, by means of the quench-reaction control (R_3, Fig. 5).

The feeder was coupled to the grid coil of the detector by means of the small single-turn coil L_3 (Fig. 5).† This coupling was not at all critical, though, of course, it affected the optimum setting of the reaction controls. Under ordinary working conditions, the amount of signal-frequency reaction (controlled by the filament rheostat, R_1) was not critical (so long as the valve was oscillating, of course, for super-regeneration) though careful control of the quench reaction was essential.

The final stage was the calibration of the receiver. This was carried out with the aid of the transmitter oscillator and a pair of Lecher wires coupled to its feeder terminals. The receiver was situated at the far end of the same room, and tuned as closely as possible to the transmitter frequency, this being checked upon the Lecher wires, for each individual setting of the tuning dials.

This provided an accurate calibration, as the receiver tuning was very sharp, but, unfortunately, the greatest frequency range possible upon the transmitter only covered a portion (about $\frac{1}{4}$) of the receiver tuning scale.

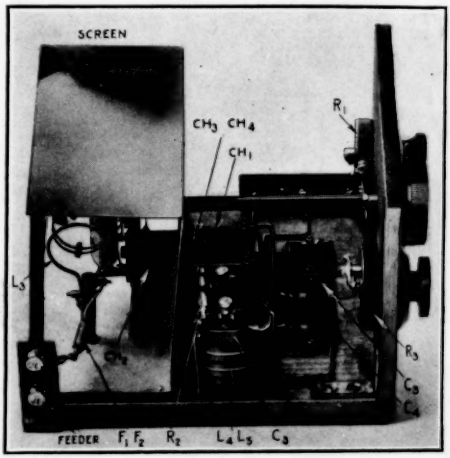
Eventually, however, this difficulty was solved (with the aid of the "quench") without having to go to the trouble of building a special oscillator (or modifying the existing one) to cover the whole range.

The tuning range covered (by the receiver) proved to be as follows:—

Wavelength — 2.56—2.88 metres.

Frequency — 104—117 megahertz.

= tuning range of 13,000 kilohertz.



Side view of receiver showing the general layout of the components lettered as on Fig. 5.

After the whole of the apparatus had been constructed, and before any range tests were undertaken, some simple working tests were carried out at short ranges to find out how the apparatus "handled" in practical use. The results were very satisfactory, the following being some of the points noted:—

(1) The tuning range (even in the case of the transmitter) was sufficiently wide to accommodate ten channels of communication without mutual interference. (In the case of the receiver, 30.)

This was with the use of super-regeneration. Had it been possible to work at reasonable ranges without recourse to this, the possible channels would have been at least ten times the above numbers.

(2) The frequency band covered could be accommodated very easily without the necessity for adopting any arrangement for adjusting the precise length of aerials

* *See* Appendix, B (1).

† *I.e.*, the method shown in Fig. 4(*c*).

and feeders to suit the particular frequency in use at the moment.

(3) With the final form of the apparatus, no trouble at all was experienced from hand or body capacity effects, and it proved remarkably easy to handle. Once the receiver reaction controls had been set (in itself no difficult matter) *the setting remained good over the whole of the tuning range*, so long as no part of the apparatus was moved bodily. Thus the receiver has, virtually, a " single-dial " control. The receiver aerial coupling L_3, having been once set, need not be altered subsequently, except in emergency (*i.e.*, should the H.T. batteries become run down, and a new supply not be available, the coupling can be loosened to release part of the aerial load on the detector circuit and allow the valve to oscillate). These remarks apply also to the transmitter aerial coupling.

Finally, an investigation was made into the effect of changing the valves, and H.T. and L.T. voltages. Changing the transmitting valve for another one of the same type and make did not noticeably affect the calibration of the transmitter. A large change in the H.T. voltage supplied (250–500) made a just perceptible change in the emitted frequency (about .1 per cent.). No change in the emitted frequency was noticed within the practical range of adjustment of filament voltage (5.5–6 v.).

The receiver was rather more sensitive to changes in the H.T. voltage, but no calibration change of importance occurred within the working range (45–50 v.). Changing the detector valve, for one of the same make and type, did not cause any noticeable change in the calibration.

Stress has been laid on these points on account of the fact that some other workers seem to have had much trouble in this direction, when working with apparatus designed for use on wavelengths below 9 or 10 metres. It is rather a nuisance having partially to rebuild or recalibrate one's apparatus every time a valve has to be changed.

Whilst upon the subject of calibration and frequency checking, it may be mentioned that an absorption type wavemeter was later constructed and used in place of the Lecher wire system to check the calibration.

The only unusual feature about the wavemeter in question was its size, being only about 1½in. × 1½in. × 1½in. overall. The condenser was a small one of the " screw-down disc " neutralising type (maximum capacity about 50 micro-microfarads) and the inductance two turns, ¾in. diameter (18 S.W.G.).

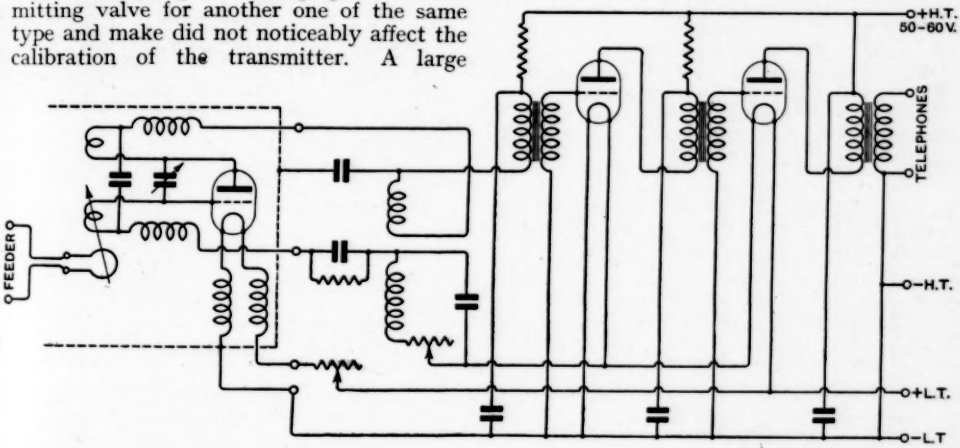


Fig. 6.

When used with the transmitter this was coupled sufficiently closely to give a decided " dip " in the reading of " X " (Fig. 4) when the transmitter frequency was varied through the resonance value.

In the case of the receiver, resonance was indicated by a sudden decrease in the quench " mush " at the point of resonance.

(*To be concluded.*)

The Measurement of Small Currents.*

Grid Current Characteristics and the Suitability of Different Types of Valves.

By Bh. S. V. Raghava Rao, M.Sc., and H. E. Watson, D.Sc.

WHILE engaged in measuring the photoelectric properties of certain substances by means of a thermionic valve, the authors were struck by the absence of data regarding the suitability of different valves for this purpose. On trial, different types of valve were found to possess widely different sensitiveness, and a more detailed investigation appeared desirable, particularly in view of the increasing applications of photoelectric cells. The most important paper on the subject hitherto published is one by du Prel (*Ann. d. Physik*, 1923, 70, 199) who by using valves of a special type at a low temperature was able to obtain a current magnification of 1.5×10^6. The present authors had only bright emitter filaments at their disposal, and it seemed probable that with modern valves, results approaching those of du Prel might be obtained without special precautions.

The circuit normally used for measuring small currents from a photoelectric cell or other source, is one in which the cell and its attendant battery are arranged so as to charge the grid of the valve either positively or negatively, and the resulting change in anode current is measured on a galvanometer balanced with respect to the initial anode current.

Since a photoelectric cell may be regarded as a source of constant current, if the grid of the valve were perfectly insulated, its potential would change by a very large amount on connecting the cell. In practice, however, equilibrium is reached owing either to grid current or to leakage. Fig. 1 shows some typical curves for a Cosmos S.P.18B valve. These were measured in the usual way by biasing the grid to a known potential, inserting a 4 megohm resistance and observing the change in anode current. It is important to note that when this is done the potential of the grid must be calculated from the bias and the potential drop in the resistance, which may be considerable. Valves of the usual 4-pin type were examined in a skeleton bakelite holder which appeared to have a very high resistance. All other leads and the photoelectric cell were supported on blocks of paraffin wax. In order to show the reverse grid current the curves are drawn with a vertical scale much larger than those ordinarily given by valve manufacturers.

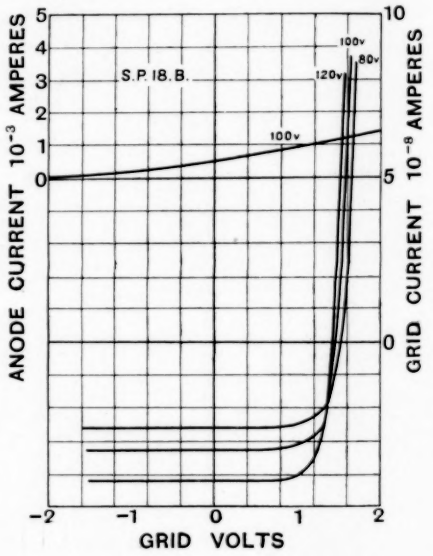


Fig. 1.

This reverse grid current as measured is the sum of the true reverse grid current due to softness of the valve and the leakage effects. It will be observed in Fig. 1 that at grid potentials less than 0.4 v. the curves become straight and the straight portion approaches the axis as the anode potential is reduced. This is precisely the effect which would be produced by leakage from the anode to the grid since a change of 1 or 2 volts in grid potential does not appreciably alter the difference between grid and anode. Nearly

*MS. received by the Editor, Oct., 1929.

all the valves examined gave curves of this type and only in one case did the curve fall to a minimum and then rise slightly at higher negative grid potentials indicating a small ionisation current.

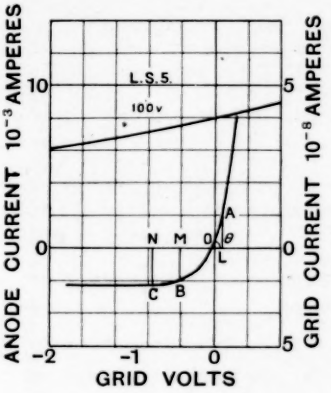


Fig. 2.

The sensitiveness of a valve for measuring photoelectric currents is best seen by considering a particular case. Fig. 2 shows grid and anode current curves for an L.S.5 valve with 100 v. on the anode and 5.0 v. on the filament. The fact that the grid current is zero at zero volts is an accident and does not affect the argument. Suppose a current of 10^{-8} amp. from a photoelectric cell is applied so as to charge the grid positively. The grid potential will be changed to L corresponding with the point A, at which the grid current is equal to the applied current. Similarly, if the grid is charged negatively the grid potential will move to M. Owing to the curvature, OL is not equal to OM, so that the change in anode current is not in general proportional to the photoelectric current, although with the S.P.18B valve of Fig. 1 it would be very nearly so for small currents. It is evident that the sensitiveness for small displacements is inversely proportional to the slope of the curve at O, and, since it is the change in anode current which is measured, is proportional to the mutual conductance M of the valve measured under working conditions and at the grid voltage at which the grid current curve cuts the axis, *i.e.*

$$\text{sensitiveness or current magnification} = M \cot \theta$$

both M and $\tan \theta$ being expressed in milliamps per volt.

If the photoelectric current is increased and makes the grid negative, a point C will be reached where the curve is nearly horizontal and a very small change in current will produce a very large change in grid potential. If the grid could be biased to the point N without increasing the leakage, great sensitiveness could be obtained. This is not very easy to do in practice but may be accomplished by using a subsidiary photoelectric cell giving a current equivalent to CN. Provided that the valve so biased has a sufficiently high anode current, a relay may readily be worked, because a very small increase in photoelectric current reduces the anode current to zero.

The above refers only to steady illumination. In the case of rapidly fluctuating illumination such as might be met with in television, the excursions of grid potential would be controlled by the capacity between the grid and its surroundings.

It appears from the foregoing considerations that, when no grid bias is used, the requirements for high sensitiveness are a large mutual conductance and a small slope

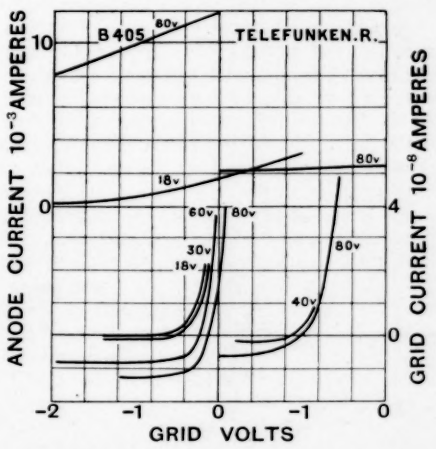


Fig. 3.

of the grid current—grid volts curve at the point where it cuts the axis, the latter being usually synonymous with high insulation. The leakage current is decreased by decreasing the anode voltage, but as this also

reduces the mutual conductance an optimum voltage is found in practice.

Figs. 3 and 4 show curves for several valves of different types, but it must be remembered that individual valves with

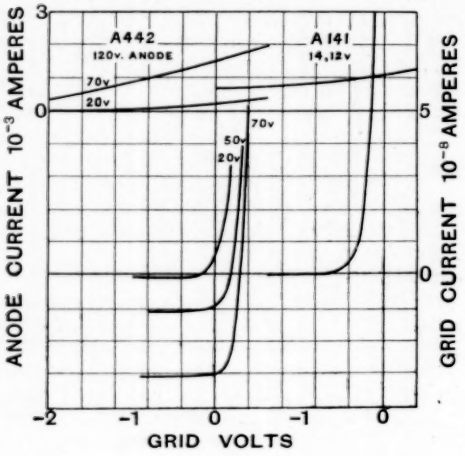


Fig. 4.

the same nominal characteristics vary considerably so that the curves must only be regarded as typical. Table I gives a selection of results for the current amplification obtained with different valves under different conditions for very small currents. It is by no means comprehensive but is intended to show the nature of the variations which can be obtained. The slopes were measured on curves plotted on a larger scale than those reproduced in the diagrams and are necessarily only approximate. The optimum conditions have not been determined for all the valves. In some cases the amplification alone was measured by applying a small known current from a silver photo-electric cell with constant illumination. The results agreed as well as could be expected with those deduced from the slopes of the curves and the method was much simpler for ascertaining the effect of varying conditions.

Among the triodes, the Telefunken valve, a very old bright emitter of the R type, was of special interest owing to its small grid current slope even at normal voltages. The current amplification was small because of the low mutual conductance. It was thought that the Cosmos valves might show abnormal behaviour owing to the unusual position at which the grid current curves cut the axis, but they did not appear to differ from valves of more normal type. The

TABLE I.

CURRENT AMPLIFICATION OF DIFFERENT VALVES.

Valve.	Anode Volts.	Subsidiary Grid Volts.	Anode Current Slope a, ma./v.	Grid Current Slope b, ma./v. $\times 10^3$	Magnification. $a/b \times 10^{-4}$
Telefunken, R.	80	—	0.1	3.7	0.27
	40	—	0.06	2.0	0.30
L.S.5	100	—	1.2	10.0	1.2
	50	—	—	—	1.7
	30	—	—	—	5.2
	20	—	—	—	4.1
C.T.25B. i ..	80	—	0.33	18.0	0.18
ii ..	80	—	0.50	19.0	0.26
	60	—	—	—	0.50
	40	—	—	—	0.63
	20	—	—	—	0.37
iii ..	80	—	0.40	10.0	0.40
Cosmos 18B ..	100	—	0.50	34.0	0.15
	40	—	0.20	9.0	0.22
18R ..	80	—	0.80	14.0	0.57
	18	—	—	—	1.3
Philips B405 ..	60	—	2.2	11.0	2.0
	40	—	1.2	2.0	6.0
	30	—	0.9	0.7	13.0
	18	—	0.5	0.14	36.0
	14	—	0.3	0.1	30.0
	10	—	0.2	0.08	25.0
Philips A435 ..	130	—	0.55	2.25	2.4
	70	—	0.21	1.5	1.4
	50	—	0.12	1.0	1.2
Loewe 2 H.F. ..	80	10	0.12	11.0	0.11
Philips A141 ..	14	12	0.25	0.4	6.3
	14	10	0.25	0.42	6.0
	10	10	0.25	0.45	5.5
Philips A442 ..	120	70	0.75	30.0	0.25
(Screened grid)	120	20	0.20	1.7	1.18
	40	18	0.16	0.9	1.8
Marconi F.E.2 (a)	40	20	—	—	1.3
	20	20	—	—	0.8
	10	20	—	—	0.75
	20	10	—	—	4.3
	10	10	—	—	21.5
	6	10	—	—	21.5
	2	10	—	—	21.5
	6	6	—	—	8.7
(b)	20	20	—	—	0.66
	10	10	—	—	3.2
	6	10	—	—	4.0
	6	6	—	—	4.8
Philips 443 i ..	50	50	—	—	26.0
(Pentode) ..	40	40	—	—	34.0
	20	20	—	—	25.0
ii ..	50	50	—	—	0.6
	20	20	—	—	1.0
	12	12	—	—	0.9

NOTE.—For the F.E.2 valve, values (a) were obtained with the auxiliary source of potential connected to the outer grid and (b) with this connection to the inner grid. Other four electrode valves were used with normal connections.

results for the Cleartron C.T.25B refer to three different valves, the variation being very marked. The Philips A435 is one in which the grid lead enters at the top of the valve and the effect of the improved insulation is seen in the comparatively small change of grid current slope with anode voltage. At 50 volts, however, the anode current becomes almost zero, and hence, in this case, reduction of anode voltage leads to reduced magnification. The Philips B405, a valve with a normal impedance of 2,100 ohms and mutual conductance 2.4, gave a higher current magnification than any other valve tested but the optimum anode voltage was found to be very critical.

As the best results were obtained with low anode voltages it seemed that tetrodes might be particularly suitable for these measurements and several were tried. The Philips A141, a 1 volt valve with an extra terminal on the cap, gave good results but not equal to those of the B405. If uncapped the performance would probably be much improved. A Marconi F.E.2, a bright emitter of the V24 type, gave high magnification even when the anode was at a lower potential than the positive end of the filament. The filament of this valve requires some 9 watts and the glass in consequence becomes very hot. With a coated filament it is not improbable that the performance of the B405 would be exceeded.

Two Philips pentodes were examined ; one gave disappointing results presumably owing to defective insulation, the other was very satisfactory.

As may be seen from the grid current curves, the magnification does not in general bear a linear relation to the grid current. Fig. 5 shows this relation more clearly for the B405 valve at different anode voltages. The curves were obtained by using a silver photoelectric cell at varying distances from a quartz mercury arc, the absolute value of the photoelectric current for one distance being deduced from the slope of the grid current curves of an L.S.5 and a Cleartron 25B valve, the two giving concordant results. The values for the magnification are distinctly higher than those recorded in Table I, but are comparable among themselves. The two sets of experiments were made at different times and the variation is quite possibly due to differing atmospheric humidity. It will be seen that in order to obtain a linear relation, comparatively high anode voltages must be used with a corresponding decrease in sensitiveness. The curve for 14 volts is shown as rising to a maximum and then falling again, the top of the curve being dotted as its exact shape has not been investigated. This maximum exists in all cases and corresponds with the applied current which reduces the anode current to zero, this being the maximum possible change on the negative side. An increase in applied current produces no further change in anode current and consequently the magnification falls off in a hyperbolic curve. The maximum magnifications obtained with 18 and 30 volts were 3.4×10^6 and 5.2×10^6 for applied currents of 2.5×10^{-10} and 5×10^{-10} amp. respectively. These are distinctly larger than du Prel's best results, which were of the order

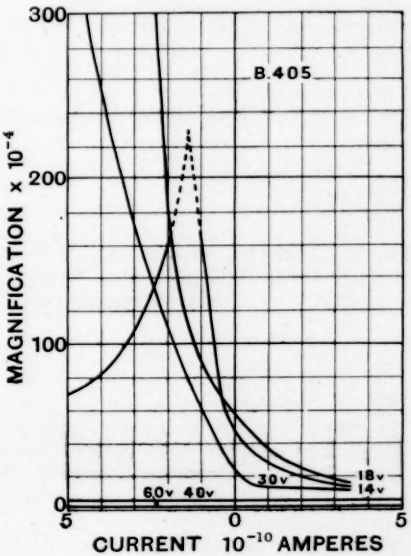


Fig. 5.

1.5×10^6. If the grid is biased by applying a steady current, still greater values can be obtained for a small change. For example, with 30 volts on the anode an applied grid current of 4.5×10^{-10} amp. produces a change in anode current of $1{,}350 \times 10^{-6}$ amp. and a current of 5.0×10^{-10} amp. a change of $2{,}600 \times 10^{-6}$ amp., consequently the

additional 0.5×10^{-10} amp. gives rise to a change of $1{,}250 \times 10^{-6}$ amp., a magnification of 25×10^{6}. The present investigation has not been extended to this region, but it is found that larger values are obtained with higher anode voltages than those which give optimum results without bias. With magnifications of this high order the problem becomes almost entirely one of stability, and this aspect has been dealt with to some extent by Wynn Williams (*Proc. Camb. Phil. Soc.*, 1927, 23, 811) and Brentano (*Zeitsch. f. Phys.*, 1929, 54, 571).

One factor has not so far been mentioned, filament voltage. It has been found that this quantity may be varied over a wide range without affecting the magnification by more than about 25 per cent., there is, however, an optimum value for which the magnification is a maximum and it is desirable to work at his point from considerations of stability. This optimum voltage is lower than the normal voltage, being 2.66 volts in the case of the 4 volt B405.

To summarise, the main requirements in a valve to give high magnification of small D.C. currents are :—extremely good insulation of the grid (a conducing factor being low filament temperature), high mutual conductance and low impedance. The best type would probably be one in which the grid connection and supports were attached to the side or end of the valve and were entirely independent of the filament-anode assembly.

The highest magnification is obtained by using anode voltages much lower than would be normally employed, the probable reason being the reduction of leakage, for this reason tetrodes are of value.

For linear magnification the amount of magnification must be sacrificed. The best results are obtained when the grid is charged positively and the anode voltage is higher than that required for maximum magnification.

If the leakage is neutralised, for example by the current from a subsidiary photoelectric cell, higher anode voltages may be employed and a very high degree of magnification obtained which depends in practice on the stability of the apparatus.

Note.—Since this paper was written Mulder and Razek (*Journ. Opt. Soc. Am.*, 1929, 18, 466) and Teegan (*Nature*, 1929, 124, 91) have both described the use of xylol-alcohol grid leak for obtaining the necessary bias for high sensitivity.

A Compensated Vacuum Tube Voltmeter with Balanced Bridge Output.*

By W. G. Hayman, B.E., B.Sc.†

THE present note is concerned chiefly with the output or indicator circuit of the single tube thermionic voltmeter rather than the general principles of design of the instrument, which have been fully discussed elsewhere. (Bib. 1–14.)

The input impedance of various types, lowest in the case of diodes and highest in those designated as " anode bend rectifiers," forms a convenient means of classification, and is also a criterion for the use of a particular type in any specific circumstances.

In the case of anode rectification it has been shown analytically (Bib. i and ii) that the governing factor is a term involving $\frac{dg_m}{de_g}$, the slope of the $g_m - e_g$ curve.

The $i_a - e_g$ characteristic of a P.M.1.L.F. valve operating at a filament voltage of 2 and an anode potential of 60 volts is shown in Fig. 1 (curve 1). The slope of this curve $\frac{di_a}{de_g}$ or the mutual conductance (g_m) is depicted to an arbitrary scale in Curve 2, whilst Curve 3 shows the result of a second differentiation, viz., $\frac{dg_m}{de_g}$.

A comparison of the latter curve with Fig. 2, which gives the change in anode

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† Hackett Research Student, University of Western Australia.

current $\triangle i_a$ occasioned by the application of an alternating e.m.f. of one volt to the grid of the valve at different values of steady grid bias, shows satisfactory agreement both in general shape and also in the value

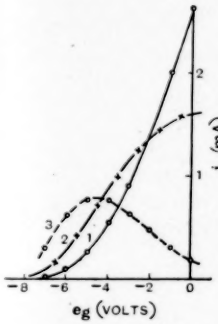

FIG. 1

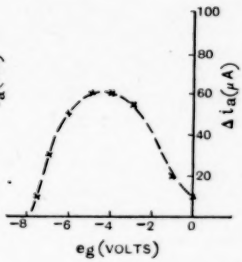

FIG. 2

of grid potential for maximum rectification efficiency.

The simplest form of thermionic voltmeter (Fig. 3a) consists of a valve with the grid biased to the "anode current cut-off" point, but the rise in detecting efficiency as the point of sharpest curvature of the characteristic is reached indicates that this type will be considerably less sensitive than one biased to the optimum detecting point.

In order to utilise the maximum sensitiveness attained at a grid potential of $-4\frac{1}{2}$ volts, it becomes necessary to neutralise or "back off" the steady anode current of about 370 microamps. Methods of balancing out this steady component are well known, but are illustrated in Figs. 3b and 3c for completeness. A separate battery is there shown, although the use of the voltmeter L.T. or H.T. batteries is very common.

In all these methods it is essential to shunt the galvanometer before any circuit variations are made, otherwise damage may be done to the instrument as the result of

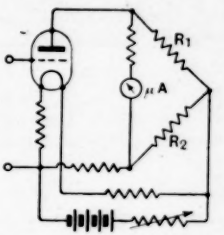

FIG. 4

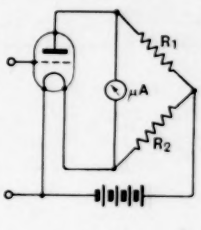

FIG. 5

the unbalanced anode or "backing off" current passing through the instrument.

A bridge method in which this danger is removed and the galvanometer immunised from accidental current unbalance has been

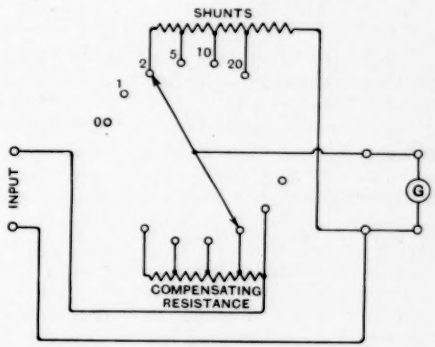

FIG. 6.

described by Hoare (11) and is shown diagrammatically in Fig. 4. Professor Appleton has also used the bridge circuit shown in Fig. 5 in which the filament of the rectifying valve forms one arm of the bridge, and thus saves the galvanometer if the filament burns out, since the filament break automatically opens the battery circuit.

Another advantage of the bridge connection is that the balance is independent of the resistance of the instrument, so that once a correct zero is attained, shunting the instrument

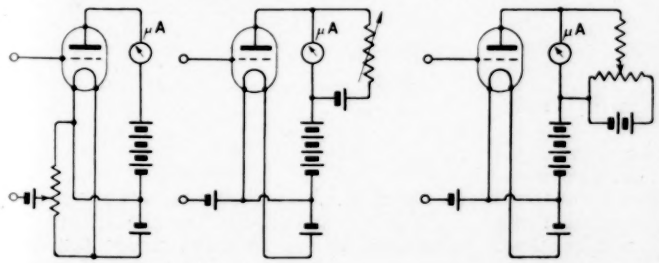

FIG. 3.

does not disturb this condition, although the sensitivity of the instrument will be modified slightly by the shunting effect of R_1 and R_2.

A useful instrument shunt which whilst altering the sensitivity of the galvanometer maintains a constant circuit resistance, is

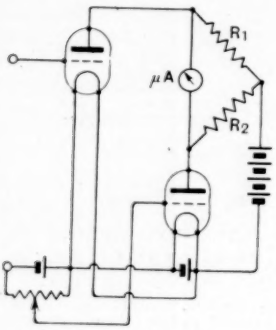

FIG. 7

invaluable for use where the galvanometer resistance enters into the balance as in an ordinary " backed off " voltmeter. Switching from one range to another entails no rebalancing, and the readings exhibit no discontinuity due to varying instrument sensitivity occasioned by changing the ratio of shunt resistance to galvanometer resistance.

Fig. 6 shows the circuit diagram of a constant resistance galvanometer shunt.

Another circuit in which the galvanometer is protected by a bridge connection is shown in Fig. 7 and schematically in Fig. 8. Since writing the above note a somewhat similar bridge circuit has been described by Winch, *Journal of Scientific Instruments*, December, 1929, Vol. VI, No. 12, p. 376.

The galvanometer is shunted across the anodes of the valves V_1 and V_2 fed by resistances R_1 and R_2.

The balance is attained when

$$(R_1 \cdot r_{a2}) = (R_2 \cdot r_{a1}),$$

where r_{a1} and r_{a2} are the static anode-filament resistances e_a/i_a.

This is effected by varying the anode filament resistance of V_2 by grid bias control. Balance is precise, stable, and easily attained even with a single potentiometer, although auxiliary resistances make the setting easier.

The use of V_2 as a complementary resistance to the rectifying valve results in a certain measure of voltage stabilising, both in the anode and filament circuits, indeed the former affects the balance and calibration so little that it can usually be neglected. Protection of the measuring instrument against current unbalance due to the burning out of the filament of one valve may be attained by connecting the filaments in series.

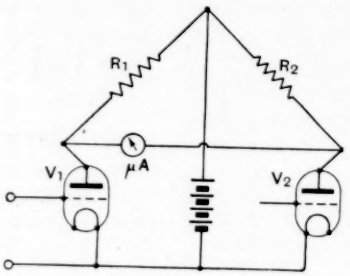

FIG. 8

A variation of $\pm$ 0.2 (10 per cent.) volt in the low tension supply produces a zero unbalance of 2½ microamps. and a change of 6 (10 per cent.) volts in the high tension supply shows a discrepancy of only 2 microamperes after a rebalance on zero input has been effected (14).

Figs. 9 and 10 show calibration curves of a voltmeter of the type described consisting

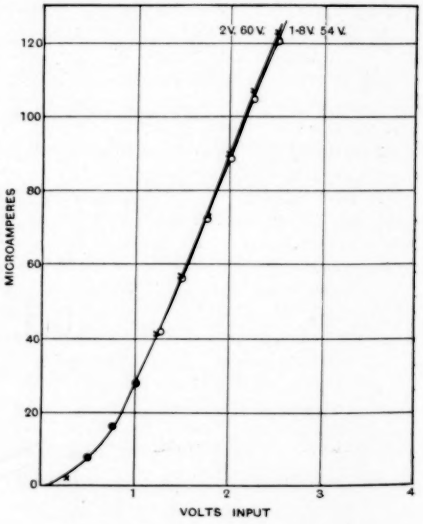

FIG. 9.

of two P.M.1.L.F. valves with appropriate resistances, and illustrates the degree of constancy to be obtained under working conditions, viz., 10 per cent. drop in each

battery vitiates the readings to the extent of only 2 per cent.

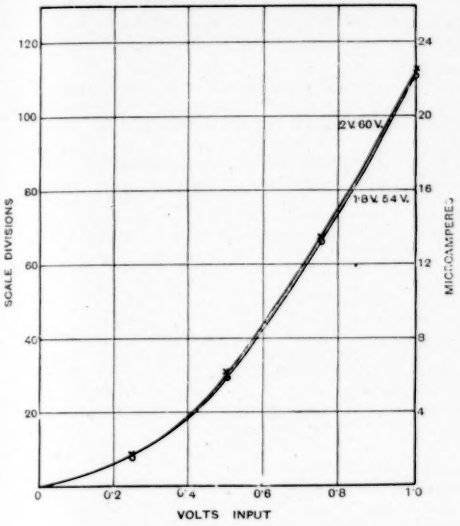

FIG. 10.

The main features of this instrument, namely, high input impedance, stability of zero and independence of calibration or anode voltage over a range of potentials likely to be experienced on any laboratory accumulator battery, together with the immunity of the galvanometer from accidental current unbalance, make the voltmeter a valuable and robust test room instrument.

The work described in the above note was carried out at the Radio Research Station, Slough, in connection with the programme of work of the Radio Research Board and is now published by permission of the Department of Scientific and Industrial Research.

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Abstracts and References.

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PROPAGATION OF WAVES.

FIELD STRENGTH FORMULA FOR GROUND WAVES, DERIVED FROM SOMMERFELD'S EQUATION.—B. van der Pol. (*Tijdschr. Ned. Radiog.*, June, 1930, Vol. 4, No. 5, pp. 105–127.)

In his paper on the technical aspects of Broadcasting in Holland (*see under* "Stations, Design and Operation") the writer shows how he and Niessen, using the operational method, transformed Sommerfeld's complicated integral into the strict equivalent (for field at the earth's surface, *i.e.* $z = 0$)

$$\frac{\Pi(r)}{k_2^2} = \frac{1}{r} \cdot \frac{k_1 k_2}{k_1^4 - k_2^4} \cdot \int_{u=\frac{k_1}{h}}^{u=\frac{k_2}{h}} e^{jhru} \cdot d(u^2 - 1)^{-\frac{1}{2}},$$

in which the Bessel function disappears and h is defined by

$$h^2 = \frac{k_1^2 k_2^2}{k_1^2 + k_2^2}; \quad [k_1 \text{ and } k_2$$

are as in the Sommerfeld equation, where $k_1^2 = \frac{\omega^2}{c^2}$ and $k_2^2 = \frac{\epsilon_2 \omega^2 + j\omega\sigma_2}{c^2}$, ϵ_2 and σ_2 being dielectric constant and conductivity of the ground respectively].

When $|k_2^4| \gg |k_1^4|$, as is the case for waves longer than 200 m. over ground in Holland, and when r is taken greater than several wavelengths ($k_1 r \gg 1$), this equation can be reduced approximately to

$$\Pi(r) = \frac{e^{jk_1 r}}{r} \cdot y(\rho) \qquad \ldots \quad (5)$$

where $y(\rho)$ is a function depending on the Sommerfeld "numerical distance" ρ. This quantity ρ, provided the ground is not too poor a conductor and the wavelength not too short ($\sigma_2 \gg \epsilon_2 \omega$; conduction current $\gg$ displacement current) can be written

$$\rho = \frac{\pi \cdot 10^{-15}}{6\sigma} \cdot \frac{r_{km}}{\lambda^2_{km}},$$

where σ is σ_2 expressed in c.g.s. units.

A table showing the values of $y(\rho)$ for various values of ρ is given, taken from Rolf's paper (Jan. Abstracts, p. 29). An empirical formula, valid within a few per cent. over the whole range of ρ from 0 to 50, is :—

$|y(\rho)| = \frac{2 + 0.3\rho}{2 + \rho + 0.6\rho^2}$; for large values of ρ, such as $\rho > 20$, $|y(\rho)| = \frac{1}{2\rho}$ approximately.

Since, in equation (5), $y(\rho) \cdot r^{-1}$ varies with r only slowly compared with the factor $e^{jk_1 r}$, for the evaluation of the field strengths E_s and H the latter factor can be differentiated, giving :

$$E_s = H = k_1^2 \cdot \frac{e^{jk_1 r}}{r} \cdot y(\rho)$$

or $$|E_s| = |H| = \frac{k_1^2}{r} \cdot |y(\rho)|.$$

For *infinitely* conducting ground, $\rho = 0$ and $y(\rho) = 1$. In this case the well-known expression (derived direct from Hertz) is valid, namely

$$|E_s| = |H| = 120\pi \cdot \frac{ah}{\lambda} \cdot \frac{I_{amp.}}{r_{km}} \quad mV/\text{metre}.$$

From the foregoing, for a ground of *finite* conductivity the equation must be

$$E = H = 120\pi \cdot \frac{ah}{\lambda} \cdot \frac{I_{amp.}}{r_{km}} \cdot y(\rho) \quad mV/\text{metre} \quad \ldots (7)$$

where E is the effective value of E_s, H the effective value of the magnetic field strength, ah the effective height of the aerial and $I_{amp.}$ the effective value of the aerial current.

If the aerial is short compared with the wavelength, the radiated power W is given by

$$W_{watt} = 160\pi^2 \left(\frac{ah}{\lambda}\right)^2 \cdot I_{amp.}^2,$$

whence by (7) the following practical formulæ are reached :—

$$E = H = 300\sqrt{W_{kw}} \cdot \frac{y(\rho)}{r_{km}} \quad mV/\text{metre},$$

or, using the empirical approximation given earlier for $y(\rho)$,

$$E = H = 300\sqrt{W_{kw}} \cdot \frac{1}{r_{km}} \cdot \frac{2 + 0.3\rho}{2 + \rho + 0.6\rho^2} \quad mV/\text{metre},$$

giving the effective values E and H of the field strengths at the surface of the earth, in terms of the total radiated energy in kw., the distance in km., and the "numerical distance" ρ, the expression for which is given earlier.

The first actual measurements, to obtain a value for the radiated power of the station, are carried out at close quarters, so that $\rho \ll 1 \ll k_1 r$; for under these conditions, the above formula reduces to

$$E = 300\sqrt{W_{kw}} \cdot \frac{1}{r_{km}} \quad mV/\text{metre}.$$

For a 299 m. wave, these conditions are fulfilled for Holland for a distance $r = 3$ to 6 km. (σ being of the order of 10^{-13} for Holland, except over sea) and measurements are therefore made at various distances in this range and the mean value of $E.r$ taken. In this way the effective power radiated is found (thus $E.r$ varied from 85 to 119, with a mean

of 100 ; so that for the station in question—Hilversum 299 m.— $W = 0.11kW$.). Having found W in this way, the field strengths at greater distances can be dealt with by the complete formula : if E is measured, σ can be found, or if values are assumed for σ, E can be calculated. Values of σ found by these 299 m. wave tests, in various directions and over various distances, ranged from 2.5×10^{-14} to 75×10^{-14}.

In all the above, the effects of the earth's curvature and the Heaviside layer are neglected. On pages 111 and 112 the writer considers them briefly. He quotes measurements by Appleton and P. P. Eckersley showing that the field strength E' at ground level, due to the space wave, for broadcasting wavelengths and distances between 30 and 1,000 km., is of the order of 0.1 mv/metre per kw. of radiated energy, so that $E' = 0.1\sqrt{W_{kw}}$ mv/metre. To avoid fading trouble, the direct signal must always be stronger than the space wave signal. Taking as the extreme limit $E' < \frac{1}{3}E$, and combining the above equation with the final practical formula already given, it follows that the greatest distance at which fading-free reception can be expected is given by $r_{km} < 10^3 \times y(\rho)$ or using the empirical expression for $y(\rho)$, by

$$r_{km} < 10^3 \times \frac{2 + 0{\cdot}3\rho}{2 + \rho + 0.6\rho^2}.$$

SOME SIMULTANEOUS OBSERVATIONS ON DOWNCOMING WIRELESS WAVES.—E. V. Appleton and J. A. Ratcliffe. (*Proc. Roy. Soc.*, July, 1930, Series A, Vol. 128, No. 807, pp. 133–158.) [*Cf.* August Abstracts, 1930, p. 446.]

Authors' summary :—Simultaneous measurements of the equivalent height and reflection coefficient of the ionised layer for 400-metre waves have been made at different distances from a wireless transmitting station. The equivalent height was found not to vary markedly with the distance between the transmitting and receiving stations. Additional evidence of night-time penetration of the Kennelly-Heaviside layer (E region) by 400-metre waves has been found. On such occasions, after reflection has taken place by a still higher region F, the re-formation of E region is observed practically simultaneously at different receiving stations.

The lack of marked variation of the reflection coefficient of the layer with angle of incidence, which has been found experimentally, is interpreted as indicating the existence of an absorbing zone situated at a lower level in the atmosphere than the region responsible for the deviation of the waves.

ON SOME SHORT-WAVE EQUIVALENT HEIGHT MEASUREMENTS OF THE IONIZED REGIONS OF THE UPPER ATMOSPHERE.—E. V. Appleton and A. L. Green. (*Proc. Roy. Soc.*, July, 1930, Series A, Vol. 128, No. 807, pp. 159–178.) [*Cf.* August Abstracts, 1930, p. 446, and foregoing abstract.]

Authors' summary :—The results of a series of measurements of the equivalent heights of the ionized regions in the upper atmosphere are described and discussed. The measurements were made using 100-metre waves which were emitted by a sending station at Teddington and recorded at London, Cambridge and Peterborough. Evidence showing the existence of two deflecting regions was obtained, the equivalent heights of which were about 100 km. and 230 km. during the daytime. The lower region (E region) was found to reflect only in the daytime, and then usually only in the middle of the day. Agreement in the equivalent heights measured at the three stations was obtained by assuming that at the near receiving station (King's College, London) interference between a downcoming ray and a ground ray took place, while at the most distant station (Peterborough) interference between a singly reflected ray and a doubly reflected wave produced the recorded signal maxima and minima. The equivalent height of the Kennelly-Heaviside layer (E region), in the early morning, is shown to be greater for 100-metre waves than for 400-metre waves.

REFLECTION OF RADIO WAVES FROM THE SURFACE OF THE EARTH.—L. C. Verman. (*Phys. Review*, 1st June, 1930, Series 2, Vol. 35, No. 11, p. 1425.)

Abstract only. The reflection of an elliptically polarized electro-magnetic wave from partially conducting and perfectly conducting surfaces is studied in detail. It is shown that in either case the interference of incident and reflected waves gives rise to a pseudo-stationary wave field above the surface of the reflector. This field is bodily propagated along the horizontal projection of the direction of the incoming wave, with a velocity greater than that of light, *i.e.*, $c/\sin\alpha$, where α is the angle of incidence. The resultant electric and magnetic vectors at any given point above the reflector describe two field ellipses lying in two different planes, whose orientation vary with height. This fact is made the basis of experimental measurements.

It is found that the 43-metre wave from WIZ, located in New Brunswick, N.J., holds its polarization and angle of incidence constant during morning hours at Ithaca, N.Y. The rapid fading that accompanies the signal is to be attributed to amplitude fluctuations. Observations on this station are analysed on the basis of the above theory to obtain the angle of incidence and the polarization of the incoming wave. Polarization is found to be generally elliptical.

PROPAGATION OF WAVES NEAR RAILWAY LINES.—H. Engel. (*Die Sendung*, 4th April, 1930, Vol. 7, p. 229.)

Experiments are described with a highly selective frame receiver situated near to a railway line and tuned to the broadcasting stations at Berlin (Witzleben, 50 km. away) and Hamburg (200 km.), with a view to testing whether propagation was helped by the existence of the iron rails and telegraph lines joining the places. The trials were in the daytime, so that reception depended presumably on the ground wave.

Berlin signals were very loud, but the receiver almost completely lost its aerial-tuning powers and its directional effect. As regards Hamburg, the

carrier wave could be recognised, but although the receiver " recovered its original selectivity " the modulation was hardly audible ; whereas far more distant stations, including Prague, could be received. It would appear that the comparatively near Berlin station had its signals helped on their way by the rails, etc., but that the more distant Hamburg station was not aided at all.

THE EFFECT OF RAIN AND FOG ON THE PROPAGATION OF VERY SHORT RADIO WAVES.—J. A. Stratton. (*Proc. Inst. Rad. Eng.*, June, 1930, Vol. 18, pp. 1064–1074.)

A theoretical investigation of the question " At what point in the radio spectrum does absorption in rain and fog, due to scattering and selective absorption, become appreciable ? " A rigorous solution of the problem, along the lines of Mie in the optics of colloidal suspensions in water, shows that the simple solution, based on Rayleigh's investigation of the scattering of light in the atmosphere, holds good for waves greater than 4–5 cms. (since for these waves it has been shown experimentally that the selective absorption in water is negligible) ; according to this, the absorption of electromagnetic waves due to scattering in rain or fog is negligible for waves greater than 30 or 40 cms. in length. The rigorous solution shows that even for a 10 cm. wave, the wave must travel 2.6×10^3 km. through a cloudburst before its intensity would be reduced to one-tenth of its original value. At 5 cms., however, the distance is reduced to 1.6×10^2 km., or 8.5×10^4 km. for moderate rain ; and below that wavelength (where selective absorption begins to add its effects) the distance decreases very rapidly, becoming only 1.3×10^2 km. for moderate rain for a 1 cm. wave.

METEOROLOGICAL INFLUENCES ON LONG-DISTANCE, LONG-WAVE RECEPTION.—E. Yokoyama and T. Nakai. (*Proc. Inst. Rad. Eng.*, June 1930, Vol. 18, pp. 1075–1083.)

The full paper, a summary of which was dealt with in June Abstracts, p. 330.

THE EFFECT OF CYCLONES AND ANTICYCLONES UPON THE INTENSITY OF RADIO SIGNALS.—R. C. Colwell. (*Phys. Review*, 1st June, 1930, Series 2, Vol. 35, No. 11, p. 1425.)

Abstract only. More on the subject dealt with in July Abstracts, pp. 388–389. Observations made up by the signal variation of station KDKA at Pittsburgh have shown that the signal intensity increases after nightfall provided there is a low pressure area between Pittsburgh and Morgantown. Hence an increasing intensity after nightfall is an indication of cloudy or stormy weather the next day. An area of high pressure between Pittsburgh and Morgantown will cause the night signal to decrease, so that this type of signal curve indicates fair weather. If the low pressure area passes south of Morgantown, it does not affect the signal. Such a low pressure brings rain with an east wind changing to north and a storm of this kind is unpredictable by observations upon a station to the north of the observer. As with the barometer, the readings indicate weather conditions twenty-four hours in advance.

ECLIPSE OBSERVATIONS AT POULO CONDORE (INDO-CHINA).—J. B. Galle. (*L'Onde Élec.*, July, 1930, Vol. 9, pp. 312–348.)

Second and final part of the paper dealt with in September Abstracts, p. 500. The present part begins with an account of the measurement of the field strengths of 17–30 m. long-distance signals (from Japan and Java) before and on the day of the eclipse. Throughout that day all these signals were very disturbed, and during the middle forty minutes of the eclipse itself it was impossible to measure them : in particular, the Japanese signals reached a disappearing point at the moment of totality. This forty minutes period was almost exactly the period during which the d.f. perturbations were observed on the local signals from a station 175 km. away—*see* below.

Atmospherics results :—The methods are described (due to Bureau) and curves given and discussed for several days preceding the eclipse. The curve of the eclipse day itself is interpreted as follows :—when the darkness was sufficient, the night atmospherics superposed themselves on the normal afternoon atmospherics ; at totality, the latter important group disappeared suddenly, causing a sharp drop in the combined number of atmospherics which lasted till 20 minutes after the end of the phase of totality, when the curve resumed almost its normal appearance for the time of day. " The observed phenomena had been foretold by Captain Bureau. They seem clearly to justify the oft-made hypothesis that the day atmospherics are of local origin, those of the night coming from distant regions."

Directional results :—On a coast station 175 km. away, very near the zone of totality, transmitting on 670 m. The breadth of the inaudibility zone on the frame aerial adjustment suddenly became 3.6–5.6 times larger about 3 minutes before the setting-in of totality, and kept this high value until several minutes after the end of this phase, when it returned slowly towards its normal value, reaching this in about 25 minutes. In addition to this broadening of the minimum, the effect of the eclipse was to give an apparent displacement of the transmitting station towards the east.

The paper then deals with observations on the total solar activity, on the conductivity of the air (a decrease of about 30%, an hour after totality and lasting about 1½ hours ; the same difference was found before and after sunrise several days later) ; and on the variation of the magnetic elements and the electric field (no very definite influence of the eclipse was established).

SUR LA RÉFRACTION DES ONDES ÉLECTRIQUES (λ = 12 cm.) DANS QUELQUES ÉLECTROLYTES (The Refraction of 12 cm. Waves in Certain Electrolytes). — K. Zakrzewski and T. Nayder. (*Bull. int. Acad. Polon.*, A., No. 1/2, 1930, pp. 30–41.)

It has been found that the dielectric constant of aqueous electrolytes, for very long waves, is different from that of pure water. The writers have found that with 12 cm. waves there is no such difference, the index of refraction being always 8.

THE RECOMBINATION OF IONS IN AIR AND OXYGEN IN RELATION TO THE NATURE OF GASEOUS IONS.—Luhr.

(*See under* " General Physical Articles.")

CHANGES IN THE OZONE CONCENTRATION OF THE ATMOSPHERE.—R. Ruedy. (*Phys. Review*, 1st Feb., 1930, Series 2, Vol. 35, No. 3, p. 295.)

Abstract only of paper read before the American Physical Society, Dec., 1929.

ULTRA-SHORT WAVES FOR BROADCASTING ?—Esau. (*See under* " Stations, Design and Operation.")

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY.

L'ÉTUDE DE LA PROPAGATION DES ONDES ÉLECTRIQUES À L'AIDE DES PARASITES ATMOSPHERIQUES (The Study of the Propagation of Electric Waves by the aid of Atmospherics).—R. Bureau. (*Comptes Rendus*, 7th July, 1930, Vol. 191, pp. 64–65.)

" The number and intensity of atmospherics received by a recorder depends on (*a*) the activity of their sources and (*b*) the propagation of the waves radiated from these sources. If we could discriminate, in the records, between these two factors, we should possess a new method of studying the propagation of waves, and without having to arrange programmes of transmission." Instead of attempting to discriminate in this way in the records taken by one recorder, the writer compares the curves taken by groups of recorders under various conditions. Thus (1) comparing the curves of two recorders tuned to two different *wavelengths*, and otherwise similar, he finds great differences often occur (" as already found by the Radio Research Board ") which may be attributed to propagation effects. These differences are small when the atmospherics come from storm centres near at hand, when propagation could have only little effect. Moreover, it is well known that the frequency of a wave has a great influence on the propagation of telegraph signals, and it is obvious that this must apply also to atmospherics.

(2) Comparing recorders arranged for different *sensitivity*, the ratio of the number of weak atmospherics to the number of strong varies with the time of day, the season, and the meteorological situation. For instance, this ratio in winter is at night above its normal values in anticyclonic conditions and polar invasions. Results up to the present lead to the supposition that the difference between the shapes of the two curves is sometimes due to the sources (*e.g.*, atmospherics arising from polar air which is unstable in summer and during the day) and sometimes to propagation effects.

(3) Records at *neighbouring stations* :—the curves at Saint Cyr and Mont Valérien (20 km. apart) show quite large differences. Since these disappear when the atmospherics come from near-by storms, and since they show, in general, a very stable and very pronounced daily variation, it seems reasonable to attribute them to propagation effects.

(4) Records in different *directions* :—all goniometric measurements, by locating the situation of the source, " allow the influence of propagation to be isolated within certain limits. D.F. recorders registering the mean directions can thus render great service."

INTERIM REPORT ON OBSERVATIONS OF ATMOSPHERICS WHICH MAY BE CAUSED BY METEORIC SHOWERS.—E. Yokoyama. (*Proc. Imp. Acad.*, Tokyo, No. 4, Vol. 6, 1930, pp. 154–157.)

The Laboratory acted on the suggestion of Nagaoka, writing from the U.R.S.I. meeting in Brussels in 1928 :—" . . . the statics observed in various countries may be a surface phenomenon ; there is still some doubt that the clicks and grinders are excited in the upper atmosphere. To decide this question, it seems to me quite interesting to record the statics during the intrusion of August and November meteoric showers." The present observations were made on a wavelength of 10,000 m. The first set, during the Leonids of November, 1928, seemed to give positive results ; grinders lasting several minutes were observed, whereas on normal days they never lasted more than a minute. Their strength was not abnormally great, and they gave no indication of directional property. Clicks were not more numerous than usual.

The Quadrantids of January, 1929, gave less definite results ; fairly strong, long grinders were observed round about the maximum of the shower, but were also found several days later. The Perseids of August, 1929, gave grinders with an average length of only 1 minute, while the Leonids of 1929, unlike those of 1928, gave an average length of less than 1 minute.

Similar observations will be made on short waves, which in general seem to be more affected by cosmical phenomena.

ECLIPSE OBSERVATIONS ON ATMOSPHERICS AT POULO CONDORE.—Galle. (*See* under " Propagation of Waves.")

MESURES DE L'IONISATION, DU CHAMP ÉLECTRIQUE ET DES ATMOSPHÉRIQUES AU MONT BLANC (Measurements of the Ionisation, Electric Field and Atmospherics on Mont Blanc).—J. Lugeon. (*Comptes Rendus*, 16th July, 1930, Vol. 191, pp. 110–112.)

Results :—(1) The mean daily value of the number per cm^3 of small ions, + and −, is practically the same at 2,450 m. and 4,358 m. altitude (but it is to be noted that the geological conditions at the lower altitude favoured the production of small ions, whereas the upper situation, on a little rock above the glaciers, was free from any such influence). (2) The amplitude of the daily variation in ionisation increases with altitude, as soon as 2,450 m. is passed. While at this altitude the day and night charges are practically equal, 2,000 m. higher up the production of + ions is 3 times larger at night than by day, and of − ions 6 times larger by night than by day.

(3) By day, the number of ions of both polarities diminishes with altitude, being 2 − 4 times smaller at 4,358 m. than at 2,450 m. By night the effect is reversed, the ionisation being up to 1½ times

greater at the higher than at the lower altitude. (4) By day and by night there is an excess of + ions at the lower levels, while above 4,000 m. the − ions seem to predominate at night. (5) The variations of ionisation are not synchronous at two stations 3 km. apart and separated by a layer of air 2,000 m. high.

(6) At the two extreme stations—2,450 m. and 4,358 m.—the electric field variations bear no relation to the ionisation.

(7) There is some correlation between the simultaneous variations of field at 4,358 m. and 3,050 m., while at the same moments, at 2,450 m., the electrometer moves " anyhow."

(8) The mean potential gradient is practically the same at 3,050 m. and 4,358 m., whereas at 2,450 m. it is markedly less.

All the above measurements were taken so as to be free from meteorological influences. On another occasion a cold front, meeting warm masses of air and forming a thick bank of mist, moved progressively past the three stations, the bank of mist rising at the rate of 23.5 m./min As it passed each station a marked fall of potential and an increase of ionisation took place. At its upper surface + ions were in excess, while in the interior the ionisation, as it increased, gained more −ions than +.

The atmospherics observed at 4,358 m. and at the summit of Mont Blanc, at sunrise and sunset, presented practically the same anomalies as on the plain. *Wireless reception at night was at least three times stronger at 4,358 m. than at 2,500 m.*, owing to the air conductivity at night being about 5 times greater at 4,358 m. than at 2,500 m. or lower.

Ionisation et Champ électrique à El Goléa (Ionisation and Electric Field at El Golea).—J. Lugeon. (*Comptes Rendus*, 28th July, 1930, Vol. 191, pp. 216–218.)

Variation diurne du Champ électrique de l'Air à l'Observatoire de la Côte de Landais. (Diurnal Variation of the Atmospheric Electric Field at the Puy de Dôme Observatory—Landais Coast).—E. Mathias and G. Grenet. (*Comptes Rendus*, 28th July, 1930, Vol. 191, pp. 187–190.)

Among the results, the combined observations of the most regular days show that the spring and summer variations " strangely resemble " the autumn and winter variations at Val Joyeux (*cf.* Sept. Abstracts). Combining the observations of every day, a marked accentuation of the afternoon minimum is found : the influence of the negative values during the afternoon is so great in summer that this minimum becomes negative and below that at 3 a.m.

The Electric Space Charge in the Lower Atmosphere.—J. G. Brown. (*Phys. Review*, 1st Jan., 1930, Series 2, Vol. 35, No. 1, p. 135.)

Abstract only of paper read before the American Physical Society, Dec., 1929. " During the past year continuous records of space charge have been obtained 7.5 meters above the earth's surface. . . . The mean value of the positive charge has been about 0.10 e.s.u. per cubic meter. . . . If the air is still the space charge is remarkably constant, but if in motion sudden changes occur. This fact has led to the conclusion that most variations at a given point are due to different bodies of air which have different charges. At night when the air becomes saturated the positive space charge decreases and negative charge often occurs. During rain large positive or negative charge results. The mean diurnal variation is almost the reciprocal of the temperature variation, though there is a decided tendency to agree with the potential gradient. Sudden changes in space charge are accompanied by corresponding changes in potential gradient, though many changes in potential gradient are not accompanied by changes in space charge."

Variation of the Electric Potential Gradient in the Lower Atmosphere.—J. G. Brown. *Phys. Review*, 1st Jan., 1930, Series 2, Vol. 35, No. 1, p. 135.)

Abstract only of paper read before the American Physical Society, Dec., 1929. " Continuous records of potential gradient and space charge have been obtained for a year 7.5 metres above the surface and their diurnal variations compared with the diurnal system of convection as inferred from the meteorological elements. In general upward currents near the surface correspond with increased charge and potential gradient, while downward correspond with decreased. General expansion and overflow above correspond with decreased charge and potential gradient, while cooling and inflow above correspond with increased. . . . Dust, smoke and condensation are important factors but are believed to be of secondary importance in determining the mean diurnal variation."

Relation entre certaines Composantes périodiques de l'Activité solaire et de l'Amplitude diurne de la Déclinaison magnétique (A Relation between certain Periodic Components of Solar Activity and the Daily Values of the Magnetic Declination).—H. and —. Labrouste. (*Comptes Rendus*, 21st July, 1930, Vol. 191, pp. 149–151.)

On the Theory of the Solar Corona.—E. O. Hulburt. (*Phys. Review*, 1st June, 1930, Series 2, Vol. 35, No. 11, pp. 1379–1383.)

A Theory of Zodiacal Light.—E. O. Hulburt. (*Phys. Review*, 15th March, 1930, Series 2, Vol. 35, No. 6, p. 663.)

Abstract only of paper read before the American Physical Society, February, 1930. *See* also August Abstracts, p. 450.

The Ultra-violet Light Theory of Auroræ and Magnetic Storms.—E. O. Hulburt. (*Phys. Review*, 15th June, 1930, Series 2, Vol. 35, No. 12, p. 1587.)

The diurnal variation phase of world-wide magnetic storms is explained as due to the gravitational magnetic drift currents set up by the polar ionic concentrations. The second phase is found to arise mainly from reactions in the atmosphere

rather than from induced currents in the earth. *Cf.* January Abstracts, pp. 34–35.

ZODIACAL LIGHT AND MAGNETIC STORMS.—E. O. Hulburt. (*Phys. Review*, 1st Feb., 1930, Series 2, Vol. 35, No. 3, p. 295.)

Abstract only of paper read before the American Physical Society, Dec., 1929.

THE [TWO POINT] KLYDONOGRAPH USED FOR MEASUREMENT OF THE WAVE FRONT OF ELECTRICAL OSCILLATIONS.—G. Someda. (*L'Elettrotec.*, 15th March, 1930, Vol. 17, pp. 173–176.)

In this modification of the ordinary klydonograph, a second point electrode is added; the two are connected by a condenser and one of them is shunted by an inductance or by a resistance of some hundreds of ohms. The constant A in the equation $v = V_1 (1 - e^{-At})$, characterising the wave front, is obtained in terms of the ratio V_2/V_1 of the potentials registered by the two discharges.

DEVELOPMENT OF THE NEW AUTOVALVE ARRESTER.—Slepian, Tanberg and Krause. (*Journ. Am. I.E.E.*, May, 1930, Vol. 49, pp. 361–365.)

More on the subject dealt with in April Abstracts, p. 209.

PROPERTIES OF CIRCUITS.

ON BANKS OF PARALLELED VALVES FEEDING REACTIVE LOADS WITHOUT DISTORTING THE WAVE-FORM.—W. Baggally. (*E.W. & W.E.*, Aug., 1930, Vol. 7, pp. 430–438.)

Author's summary:—"In a previous paper (*ibid.*, June, 1928) the author showed how to solve problems on power banks when the load is a pure resistance. In the present article, the theory has been extended to the case of a general impedance. It is shown that with inductive loud speakers it is not possible to work the bank under optimum power conditions with linear input, owing to distortion setting in at the lower frequencies; and a method of obviating the distortion is given" [making the grid swing follow a certain graph, between two frequencies, and remain constant—satisfying a given equation—outside these limits; thus obtaining that the valves would be accepting the maximum possible grid swing at all frequencies and that the load would be the optimum at some middle frequency. This result is obtained by a suitable filter circuit—for which the formulæ are derived—introduced into the amplifier feeding the bank]. *Cf.* Forstmann, below.

ÜBER DIE ERZIELUNG UNVERZERRTER MAXIMALLEISTUNGEN DURCH ENDVERSTÄRKERRÖHREN BEI ANWENDUNG NICHTLINEARER SCHWINGUNGEN (On the Production of Maximum Undistorted Power Output from the Final Amplifier Valves by the Use of Non-Linear Oscillation Characteristics).—A. Forstmann. (*E.N.T.*, May, 1930, Vol. 7, No. 5, pp. 203–210.)

Author's summary:—The results obtained from a consideration of the problem of power output depend on the initial assumptions made. The conditions necessary for the avoidance of distortion of oscillations with a linear detector characteristic are given; the important point in the production of an undistorted output in this case is mis-matching of valve and circuit impedances.

The question is further discussed as to what power can be obtained from a valve when non-linear oscillation characteristics are used and what conditions are necessary for the resulting oscillations to be linear.

It is shown that in the case of single-grid valves the degree of efficiency obtainable in practice is smaller than that given by screened grid valves, with which almost ideal conditions can be attained. The power obtainable may be limited by the capacity of the screen for absorbing energy. In order to make the power output (1) as independent of the frequency and (2) as large as possible, the valve impedance must in the case of single-grid valves be made much smaller than the impedance of the external circuit and, in the case of screened grid valves, much larger. *Cf.* same writer, July Abstracts, p. 390; also Baggally, above.

SINGLE- AND COUPLED-CIRCUIT SYSTEMS.—E. S. Purington. (*Proc. Inst. Rad. Eng.*, June, 1930, Vol. 18, pp. 983–1016.)

Author's summary:—This article discusses networks based upon singly-tuned circuits, and upon coupled circuits with primary and secondary both resonant to the same frequency. Transmission equations are developed and it is shown that for a desired possible transmission-curve shape, the sum of all decrement coefficients must be a certain amount, readily computable for coupled circuits as well as for single circuits.

Coupled circuit transmission-curve shapes may be developed from single-circuit curves by a multiplication process as in staggered-cascade amplification, or by a vector difference process, employing two staggered single circuits with opposite couplings from a power source. A special case of the vector difference method is the coupled circuit itself, with primary current the vector sum and secondary current the vector difference of two single-circuit currents. This property permits a suitable coupled system to be used for radiating energy of two closely adjacent channels from a single antenna without cross reactions on the power sources.

Complex networks are handled by transfer equations by which a branch consisting of a voltage source and resistor in series coupled to a network by a transformer device is replaced by an equivalent voltage and impedance within the network. Application is made to computation of interstage amplifying transformers, and of single- and two-circuit filters with resistance loading. A brief treatment is given of the impedance and power-factor loading of generator circuits which is of especial importance when tuned networks are output devices of power tubes operating at high plate efficiency.

DETECTOR DAMPING.—W. T. Cocking. (*Wireless World*, 30th July, 1930, Vol. 27, pp. 100–102.)

Measurements of the load imposed by the power grid detector. In this article, as a result of actual

measurement, the conclusion is reached that the damping due to grid current is negligible, whereas that due to the reverse reaction effect brought about by the anode-grid capacity of the valve is of large magnitude. Various methods of overcoming the trouble are described.

RÜCKKOPPLUNG ÜBER DIE GEMEINSAME ANODENSPANNUNGSQUELLE EINER VERSTÄRKERKETTE (Reaction through a Common Anode Potential Source in an Amplifier Chain).—R. Tamm. (*E.T.Z.*, 1st May, 1930, Vol. 51, pp. 631–634.)

(1) General considerations regarding reaction: definitions ($V_1 = V_0 + rV_1$, where r is the reaction factor; thus $V_1 = V_0 \cdot \frac{1}{1-r}$ or $V_0\theta$, where θ is the distortion factor. When $r = 1$, θ becomes infinite and the amplifier howls). (2) Reaction through the internal resistance of a dry battery. (3) Through an anode potential source with an internal resistance varying with frequency (*e.g.*, eliminators).

OSCILLATIONS SINUSOIDALES ET DE RELAXATION (Sinusoidal and Relaxation Oscillations).—B. van der Pol. (*L'Onde Élec.*, July, 1930, Vol. 9, pp. 293–312).

Second and final part of the paper referred to in Sept. Abstracts, pp. 503–504. A new example of the occurrence of relaxation oscillations in nature is now added to those given in the writer's previous papers, some of which were quoted in 1929 Abstracts, p. 42 :—Hamburger maintains that the recurrence of economic cycles (" business cycles " of prosperity and depression), with their comparatively constant amplitudes and varying periodicities, is explained on these lines.

SUCCESSIVE UNIDIRECTIONAL CONDENSER DISCHARGE.—S. Sano. (*Journ. Am. I.E.E.*, May, 1930, Vol. 49, pp. 370–372.)

Describes, and illustrates by oscillograms, a phenomenon of successive unidirectional discharges across a spark gap shunting a condenser, when the latter is in series with an inductance and the two are brought into resonance with an alternating e.m.f. An ordinary spherical spark gap does not give stable operation for long, but the writer's special platinum wire-spherical zinc surface gap gives very stable results. Direct current may be obtained from the system if a wave-filter is used; or the system may be employed as a generator of successive pulses of unidirectional current.

CONVERSION STATIQUE DE FRÉQUENCE ET HARMONIQUES (The Static Conversion of Frequency and Harmonics).—P. Vecchiacchi. (*Rev. Gén. de l'Élec.*, 12th July, 1930, Vol. 28, pp. 58–60.)

Long summary of the Italian paper on the " Static and Harmonic Conversion of Frequency " referred to in May Abstracts, p. 273.

TRANSMISSION.

TONE MODULATION OF TELEGRAPHIC TRANSMITTERS [FOR THE NEUTRALISATION OF FADING].—N. Wells. (*Marconi Review*, July, 1930, pp. 1–7.)

The effects of tone modulation on both the transmitter and receiver are discussed, and the article concludes with a summary of the advantages, conditions and limitations of the method. " When conditions are good and stable, in other words favourable to very high speeds, we approach the stage during which pure c.w., with its energy concentrated into a single unfading frequency, will give stronger signals and higher speeds than modulated c.w. But conditions can seldom be trusted, and modulated c.w. gives an unquestioned improvement in traffic at most times, so that some compromise seems indicated; thus in many instances and in general practice, it will be an advantage to run with a certain amount of residual c.w., provided that the system of keying is such that the whole of the received energy is available to form signals. . . . The writer has observed, while receiving signals for which the modulation has been only 30% and even less, that when conditions were in any way poor the large c.w. component has almost entirely disappeared, whereas the sidebands were still coming through to give commercially strong signals."

As regards the choice of modulation frequency, the following approximate recommendations are given :—for a wide aperture Beam Reception aerial system, or for combined " Beam " and " Diversity " reception (*e.g.*, three small beam aerial systems separated for diversity fading) a frequency of 250 cycles/sec. is suitable; for small beam aerial systems, or for Diversity reception employing three simple aerials, 500 cycles/sec.; for broadcast reception, a modulation of 1,000 cycles/sec.

SOME PROBLEMS IN SHORT WAVE TELEPHONE TRANSMISSION.—J. C. Schelling. (*Proc. Inst. Rad. Eng.*, June, 1930, Vol. 18, pp. 913–938.)

Author's summary :—In this paper are discussed certain phases of short-wave telephony, primarily, though not entirely, from the point of view of the transmitter. The field strengths which the transmitting station must provide at the receiver are considered. Typical data are given showing results obtained in transmission from Deal, New Jersey, to England. This is followed by a discussion of requirements and limitations of the transmitting antenna. The gains which arrays may reasonably be expected to provide are considered. The phenomenon of non-synchronous fading at nearby points is examined as to its bearing on the dimensions and performance of directive arrays. Other directional properties of the transmitting medium are also considered. Attention is then directed to the transmitting equipment, particular attention being given to the high-power part of it. Requirements, rather than circuit details, are emphasized. These include stability of operation, flexibility, and freedom from amplitude distortion, and phase and frequency modulation. The results of tests in which some of these matters were considered quantitatively are given.

PROPERTIES OF MODULATED SIGNALS AND MODULATION DEVICES.—R. P. Glover. (*Rad. Engineering*, May and July, 1930, Vol. 10, pp. 21–25 and 31–34.)

"An Engineering presentation of the fundamental methods of modulation by means of vacuum tubes." The second part is devoted to methods of measuring the percentage modulation, including methods employing the carrier peak (Jolliffe, 1929 Abstracts, p. 459); methods which account for total amplitude variation (van der Pol and Posthumus, *E.W. & W.E.*, March, 1927) which may be applied to the signals of a distant transmitter; cathode-ray oscillograph (Rodwin and Smith, 1928 Abstracts, p. 224; von Ardenne, July Abstracts, p. 406); methods depending on detector action (Jarvis, 1929 Abstracts, p. 459).

In the above, the writer has dealt with the maximum, minimum and peak amplitudes, but at the end he shows how the r.m.s. voltage and current values may be brought in, giving in full van der Bijl's derivation of the peak factor of a modulated wave ($k = \frac{E_{rms}}{E_{max}} = 0.707 \frac{\sqrt{\frac{m^2}{2} + 1}}{1 + m}$). This leads to a description of the use of the peak factor in modulation measurements; the objection is that k decreases rather slowly for values of m above about 0.5, so that it has to be measured very accurately; the method, however, is very useful as a check.

O NAJKORZYSTNIEJSZYCH WARUNKOCH PRACY MODULATORA DŁAWIKOWEGO (The Optimum Working Conditions of a Choke-coil Modulator).—J. Groszkowski. (*Wiadomości i Prace, Inst. Radjotech.*, Warsaw, No. 4, Vol. 2, 1930, pp. 89–101.)

The writer shows theoretically, and confirms by experiment, that in a choke-controlled transmitter, defined by the characteristics of the modulating valves and the dissipated power and efficiency of the generator, there is always a certain value of supply voltage which gives maximum r.f. output power for a given degree of modulation and of distortion.

DEFINITION DER LEISTUNG VON TELEFONIESENDERN (Definition of the Power of Telephony Transmitters).—W. Schäffer. (*Zeitschr. f. tech. Phys.*, June, 1930, Vol. 35, pp. 232–235.)

A treatment of the problem which formed the basis of the C.C.I.R. (1929) recommendation as to the definition to be adopted. For transmitters in which the aerial carrier-wave current keeps a constant value independent of the degree of modulation, the value of i in the nominal power formula $N = i^2R$ can be determined by the aerial ammeter. In transmitters in which the carrier-wave current changes with the depth of modulation, i must be derived from the peak value J and geometric mean value I of the current under the maximum allowable depth of modulation, by the formula

$$i = \frac{J}{3}\left(1 + \sqrt{6\left(\frac{I}{J}\right)^2 - 2}\right).$$

In both cases, the value of N must be supplemented by a statement of the maximum degree of modulation.

A MASTER OSCILLATOR OF HIGH CONSTANCY OF FREQUENCY.—T. D. Parkin. (*Marconi Review*, July, 1930, pp. 14–21.)

"Oscillators of the valve capacity-inductance type, intended as primary drives for broadcast stations, have certain advantages over tuning fork and crystal drives, chief among which is the fact that such an oscillator can be made tunable over a wide range of frequencies so that the wavelength of the station it is desired to control can quickly be altered if necessary. The valve oscillator described below is capable of very constant performance in spite of relatively large variations in temperature and voltage supply."

In the single-range model, a 5% decrease of low tension voltage caused a frequency change of 1 in 95,000; a 5% change in h.t. caused a change of 1 in 41,000. A change to another valve of the same type gave a variation of 1 in 95,000. In a multi-range model the changes are rather worse, but in no case does a ± 5% change of l.t. or h.t. voltage cause a change of more than 1 in 27,000.

SUR LA STABILITÉ DES POSTES ÉMETTEURS AUTO-EXCITATEURS DONT LA CAPACITÉ D'ANTENNE VARIE (On the Stability of Self-Excited Transmitting Sets whose Aerial Capacity Varies).—E. Achard. (*Bull. S.F.R.*, May, 1930, Vol. 4, pp. 58–72.)

A paper dealing with the problem, an important example of which is furnished by ship sets whose aerials undergo by no means negligible variations of capacity as a result of the movements of the ship.

LONG DISTANCE CABLE CIRCUIT FOR PROGRAM TRANSMISSION.—A. B. Clark and C. W. Green. (*Journ. Am.I.E.E.*, August, 1930, Vol. 49, pp. 642–646.)

Deals first with the transmission requirements of broadcasting systems and then describes a new cable system which has been tried with very satisfactory results on a looped-back circuit 2,200 miles long.

RADIOTELEGRAPHY AND RADIOTELEPHONY ON HALF-METRE [ULTRA-SHORT] WAVES.—Uda.
(*See under* "Reception.")

THE "SIDEBAND" ARGUMENT AND INFRA-RED TELEPHONY.—Wigge and Wigand.
(*See under* "Miscellaneous.")

RECEPTION.

MAXIMUM RANGE FOR FADING-FREE RECEPTION.—van der Pol.

(*See* abstract under "Propagation of Waves," last paragraph.)

INTERFERENCE ELIMINATION BY THE STATISTICAL METHOD.—Schröter.

(*See* abstract under "Stations, Design and Operation.")

DAS PROBLEM DER LAUTSTÄRKENREGELUNG (The Problem of Volume Control).—M. von Ardenne. (*Rad., B., F. f. Alle*, Aug., 1930, pp. 352–358.)

Beginning with the simplest forms, the writer deals in succession with volume control by :—(*a*) variable aerial coupling, inductive and capacitive : for the latter, he shows an arrangement which (by the use of a differential condenser) is free from de-tuning effect, and another in which an earthed screening plate is adjustable between the plates of the coupling condenser : (*b*) by regulation of filament rheostat, particularly for receivers with r.f. amplification which therefore require very great range of control (even up to a ratio of $1 : 10^8$). For modern mains-driven receivers with indirectly-heated valves, this method is not applicable and is replaced by :—(*c*) grid-bias regulation by potentiometer. This is extravagant for battery-driven receivers, and is replaced by :—(*d*) anode-potential regulation by series resistance (step-by-step). For mains-driven receivers the series resistance is replaced by a resistance in parallel. (*e*) Multiple application of coupling control between stages, by a double potentiometer. (*f*) Inter-stage regulation by means of the condenser with the earthed screening plate referred to in (*a*) ; this is particularly recommended. (*g*) Automatic control, anti-fading and for different stations ; two systems are given, both using an auxiliary valve, one depending on anode-voltage change, the other on grid-bias.

AN ANTI-FADING AND AUTOMATIC VOLUME CONTROL DEVICE APPLICABLE TO ANODE BEND RECTIFICATION.—C. Sansaldo. (*Revista Teleg.*, Buenos Ayres, Nov., 1929, Vol. 18.)

Chrétien's system (1929 Abstracts, p. 510) can only be applied to a receiver using leaky-grid detection. The writer's method can be applied to any existing superheterodyne receiver using plate detection, and needs only a small auxiliary battery and a variable resistance of 20,000 ohms. For a summary see *QST Franç.*, March, 1930, Vol. 11, p. 47.

THE AMPLIFICATION AND DETECTION OF ULTRA-SHORT ELECTRIC WAVES.—K. Okabe. (*Proc. Inst. Rad. Eng.*, June, 1930, Vol. 18, pp. 1028–1037.)

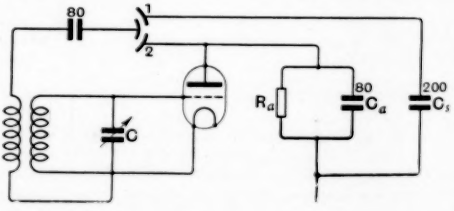
A rapid review of the various "electronic ampli-detector" circuits (triodes, or diodes with external third electrode, connected as if to generate B.-K. or Gill-Morrell oscillations) used by the writer and Uda for the reception of waves below 1 m. The name "ampli-detector" represents the fact that detection is accompanied by amplification (*cf.* same writer, April Abstracts, p. 213). Six different circuits are illustrated and discussed. Apparently the most satisfactory are the ones using a magnetic field. The paper ends with the formulation of a simple theory regarding the amplifying action : from the equations derived the writer deduces that best reception should be obtained when the frequencies of the incoming wave and of the self-sustained oscillations are equal, though in practical cases a slight difference should not be serious ; and that though the self-oscillation has no direct effect on the amplifying action, "it may arise generally whenever any satisfactory reception is obtained. These results are quite consistent with the experiments except in a few cases." See also Uda, April Abstracts, pp. 212–213 ; July, p. 392.

RADIOTELEGRAPHY AND RADIOTELEPHONY ON HALF-METER [ULTRA-SHORT] WAVES.—S. Uda. (*Proc. Inst. Rad. Eng.*, June, 1930, Vol. 18, pp. 1047–1063.)

English version of the paper in German dealt with in July Abstracts, pp. 392–393. In connection with the polar diagram of the receiving director-chain, the fact that the signals disappear so distinctly and abruptly at a certain angle "seems to prove that in our electron receiver the regenerative detection becomes suddenly ineffective when the signal strength becomes too weak to control the electron oscillations within the detector tube." Telephony was good over 10 km. and telegraphy over 30 km.

KOMPENSATION DER VERSTIMMUNG IN DER RÜCKKOPPLUNGSCHALTUNG (Compensation for the De-tuning in a Reaction Receiver).—M. v. Ardenne. (*E.T.Z.*, 24th July, 1930, Vol. 51, pp. 1060–1061.)

The de-tuning effect of reaction adjustment is counteracted in various ways in different receivers, but it becomes more and more important that it should be compensated automatically now that high-quality receivers are required to have single-knob control. The writer investigates the phenomenon of de-tuning as it occurs in a particular circuit (Leithäuser-Reinartz) and from his results shows how it can be practically abolished by the use of a differential condenser, as shown in the diagram.



Here C_s is an auxiliary condenser of the same order as, but greater than, C_a. The two stators of the differential condenser are represented by 1 and 2, while its rotor is shown opposite to them. When the rotor is opposite 1, the effective reaction capacity is zero and the reaction branch-circuit is loaded with the larger condenser C_s. As the rotor moves towards 2, so that the reaction increases, the load between anode and cathode decreases in proportion, finally reducing to C_a. The correct choice of C_s is of great importance ; it is best found by experiment.

EXPERIMENTS WITH A SCREEN-GRID REACTION AUDION. A TWO-VALVE RECEIVER WITH SCREEN-GRID AUDION.—E. Wrona. Anon. (*Die Sendung*, 1st March, 1930, Vol. 7, pp. 143–144; 27th June, 1930, Vol. 7, pp. 414–416.)

LE BRUIT DE FOND (Background Noise).—L. G. Veyssière. (*T.S.F. Mod.*, April, 1930, Vol. 10, pp. 170–185.)

In frequency-changing receivers, which exaggerate this noise, the writer considers that the discontinuous origin of the intermediate frequency may lead to the noises, if the frequencies from which this intermediate frequency is derived do not remain absolutely constant. Moreover, the effect of lack of syntony in the circuits on a wave whose frequency is modulated, and the modulation of the local oscillator frequency by the incoming modulated wave, are considered as contributory causes. Several practical conclusions are reached.

RICEVITORE RADIOFONICO DI ALTA QUALITA' (Radio-telephony Receiver of High Quality).—M. Boella. (*L'Elettrotec.*, 5th Aug., 1930, Vol. 17, pp. 511–513.)

A superheterodyne receiver for broadcast reception on medium waves, "with a remarkable selectivity and receiving with notable fidelity modulated frequencies from 25—5,000 cycles/sec." It has been designed by the Naval Research Laboratories. The intermediate frequency is 250 kc./sec.; there are three tuned anode stages, the first two differing in tune by 7,000 cycles/sec. and the third tuned to a frequency between those of the first two (*cf.* same writer, 1929 Abstracts, p. 152). Demodulation is by grid-characteristic (100 $\mu\mu$F and 0.1 megohm—*cf.* 1929 Abstracts, p. 570, and Turner, September Abstracts, page 507). Coupling to the output pentode is by transformer, with parallel feed, giving constant amplification between 15 and 5,000 cycles/sec. All the valves except the pentode are indirectly heated.

SCIENCE MUSEUM RECEIVER.—R. P. G. Denman and A. S. Brereton. (*Wireless World*, 30th July and 6th Aug., 1930, Vol. 27, pp. 96–99 and 116–118.)

A description of the new receiver designed to replace that installed in the Science Museum in 1925. In the new instrument push-pull power grid detection replaces a diode rectifier. To preserve the side-bands of the modulated transmission the single r.f. stage contains filter circuits giving a flat-topped resonance curve, whilst fidelity of reproduction in the l.f. amplifier is maintained by the use of a "paraphase" amplifier.

The output power of the apparatus is 40 watts. By assigning conservative engineering values throughout the set it has been possible to shift the onus of responsibility for overloading on to even the largest loud speaker that may be connected to it. This, in the present case, is a moving-coil unit with a 27ft. logarithmic horn having a lower cut-off frequency of 32 cycles per second, designed for use with a 555W unit and a special equaliser arrangement.

UNTUNED R.F. AMPLIFICATION.—A. C. Lescarboura. (*Rad. Engineering*, April, 1930, Vol. 10, p. 26.)

"Recent engineering development on fixed r.f. transformers, especially designed for use with the screen-grid tube, may yet bring about a change in present-day broadcast reception practice. . . . It may require more tubes to equal the gain with tuned r.f. stages, but . . . the equipment is so much more simple, so compact, and so much lower in cost. . . . In the portable set particularly . . . it may have decided advantages because of compactness and light weight. . . . It detours around most of the troublesome receiver patents now in force. . . ."

APERIODIC H.F. AMPLIFICATION. — A. L. M. Sowerby. (*Wireless World*, 2nd and 9th July, 1930, Vol. 27, pp. 2–6 and 35–38.)

That choke-coupled aperiodic r.f. amplification is still popular is shown by an analysis of the circuits used in modern portable sets. In this article the actual stage gain with various valves is measured. The interesting conclusion is reached that with triodes the anode-grid capacity causes sufficient reverse reaction effect to reduce the input to a small fraction of its original value and that amplification with such a stage occurs only by virtue of incidental and deliberate reaction. The screen-grid valve affords a partial solution to the problem.

A NEW SYSTEM OF L.F. AMPLIFICATION.—Olinet. (*See* under "Acoustics.")

SELECTIVITY AND MODULATION RESPONSE.—PART I.—R. S. Spreadbury. (*Television*, Aug., 1930, Vol. 3, pp. 268–269.)

"In a recent article I gave a brief description of experiments proving the non-existence of side-bands in modulated carrier frequencies [July Abstract, p. 393]. In the present series I propose to explain that defects attributed to side-bands are in reality due to conditions in the tuning circuits of the receiver, and to suggest ways in which the difficulties involved may be overcome." His argument may be illustrated by the following quotation:—"It is known that reaction increases both selectivity and sensitivity, but has an adverse effect on modulation response. If this modulation response be analysed, it will be discovered that the increment is greatly improved, and the decrease in the modulation response is due entirely to an abnormal reduction in the decrement [illustrated by a curve]. If the decrement can be increased, so as to have a value equal to the increment, the resultant circuit will be an advance in the right direction. A circuit giving such decrement, by applying an entirely novel reaction principle, and incorporating the neutralising-wavetrap system of tuning, will be described in the next part of this series. On test, this receiver has reproduced undistorted, intelligible speech from any station whose heterodyne whistle could be heard, and should prove especially interesting to those wishing to receive television transmissions from a distance."

THE STENODE RADIOSTAT.—(*Rad., B., F. f. Alle*, September, 1930, pp. 385–387.)

Apart from the question of high cost, the writer thinks that the advantages of this system could only be fully enjoyed if broadcast transmissions were changed over to frequency modulation; he is sceptical as to the revolutionary results of the invention.

SIDE BANDS AND SELECTIVITY [IN CONNECTION WITH THE STENODE RADIOSTAT].—G.W.O.H. *E.W. & W.E.*, Aug., 1930, Vol. 7, pp. 417–420.)

ERGEBNISSE DER IM APRIL 1929 BEI DEN BERLINER RUNDFUNKTEILNEHMERN GEHALTENEN UMFRAGE ÜBER DIE EMPFANGSVERHÄLTNISSE (Results of the April, 1929, Inquiry among Berlin Listeners as to Reception Conditions). —F. Kiebitz. (*E.T.Z.*, 7th Aug., 1930, Vol. 51, pp. 1142–1143.)

Only 10% occupy themselves with reception from distant stations, the rest concentrating on the local stations. 75% use valves. Interference is caused by oscillation (45.2%), medical apparatus (23.5%), trams, etc. (17.2%), motors (12.5%), illuminated advertisements (1.3%), and cookers (3.3%).

AERIALS AND AERIAL SYSTEMS.

RÉSISTANCE DE RAYONNEMENT D'UNE PETITE ANTENNE OSCILLANT EN DEMI-ONDE (Radiation Resistance of a Small Aerial oscillating to a Half Wave).—S. Sonada. (*Comptes Rendus*, 28th July, 1930, Vol. 191, pp. 195–198.)

An investigation of the behaviour of a half-wave aerial oscillating on a 17.8 cm. wave, generated by a Pierret oscillator. The oscillator was kept constant in amplitude and frequency, while the aerial was altered in length and a resonance curve plotted. For waves of this length, the natural wavelength of the aerial is no longer twice its length. Resonance, indicated by maximum current at the centre, is obtained when the length of the aerial is 1.8 cm. shorter than the half wavelength 8.9 cm. Calling this discrepancy $\triangle L$, it is found that $\frac{\triangle L}{L}$, for small changes of resonance, is universally proportional to the natural wavelength of the aerial, and the latter wavelength is in this way deduced from the actual length of the aerial.

If λ_0 represents the generator wavelength, and λ_1 and λ_2 the natural wavelengths of the aerial for which the deviation of the galvanometer (connected to a thermo-couple at the mid-point of the aerial) is half that at resonance, then the damping α of the aerial oscillations is $\alpha = \frac{1}{2} c\pi\lambda_0 \left(\frac{1}{\lambda_1^2} - \frac{1}{\lambda_2^2}\right)$, where c is the velocity of propagation.

The values found are $\lambda_0 = 17.8$ cm., $\lambda_1 = 15.81$ cm., and $\lambda_2 = 19.88$ cm.; giving $\alpha = 0.123 \times 10^{10}$, corresponding to a logarithmic decrement $\delta = 0.729$. The amplitude of a free oscillation is about half the amplitude of the preceding oscillation.

From this, the total resistance of the aerial is deduced. By the equations for the propagation of sine waves along wires, $\alpha = \frac{r}{2l}$, where r and l are the resistance and inductance per unit length. By Neumann's formula, the mean inductance per unit of length is found to be $l = 6.05 \times 10^{-9}$ henry, giving a total aerial resistance $rL = 105.5$ ohms. Stefan's formula gives for the ohmic resistance at the frequency in question, taking the permeability of iron at high frequencies as 74 (Laville), the value 5.5 ohms. *This leaves a value of* 100 *ohms as the radiation resistance.*

A direct calculation of the radiation resistance treating each element of the wire as a doublet and assuming that the end effects are due to localised capacities, gives 121 ohms. The discrepancy of 21 ohms is readily understood, for the end-correction is undoubtedly too great; in actual fact, the current distribution departs from the sinusoidal at some distance from the end and decreases gradually to zero. The intensity near the ends of the aerial is therefore less than assumed, so that the calculated value for the resistance is too large. The error may easily be as much as 21 ohms; the radiation resistance in actual fact changes greatly with the distribution of the current: it alters from 80 ohms, for a half-wave distribution without correction for end effects, to 197 ohms for a wire of the same length along which the current keeps a uniform value.

VALVES AND THERMIONICS.

RECTIFIER CHARACTERISTICS AND DETECTION DIAGRAMS.—R. Ruedy. (*Phys. Review*, 1st Jan., 1930, Series 2, Vol. 35, No. 1, p. 129.)

Abstract only of paper read before the American Physical Society, Nov., 1929. "The average current I_m obtained per cycle when, in addition to the constant voltage E, the potential $E_0 \sin \omega t$ is applied to a rectifier possessing the characteristic curve $I = f(E)$, has been calculated and compared with experiment for different $f(E)$. The curve $I = c\epsilon \exp[E/e_\epsilon]$ giving at open circuit a voltage independent of E applies to all types of vacuum tubes when the a.c. voltage does not exceed a few tenths of a volt, or 0.5 volt in the case of oxide-coated emitters. The curve $I = 1/E$ gives $I_m = 1/(E^2 - E_0^2)^{\frac{1}{2}}$, and applies to certain types of glow and arc discharges in which an a.c. e.m.f. is superimposed upon d.c. Parabolic curves, for which the increase in I is independent of E, represent the actual current I_m better than the theoretical curves $I = CE^{-\frac{3}{2}}$."

NOTE ON VARIATIONS IN THE AMPLIFICATION FACTOR OF TRIODES.—F. E. Terman and A. L. Cook. (*Proc. Inst. Rad. Eng.*, June, 1930, Vol. 18, pp. 1044–1046.)

The writer points out that the variations are due to different portions of the triode having different values of μ owing to edge effects and other dissymmetries. These different parts are all in parallel, so that the behaviour of the equivalent μ of an ordinary valve can be considered as the result of a parallel combination of unlike valves (the analysis of which was given by Hartley, *ibid.*, June, 1921). In a typical commercial triode μ varies between 10.4 and 8.5, or about 20%, over the operating range. This variation gives several

undesirable operating features; it prevents distortionless amplification even when the valve is operated on a straight part of its anode-voltage anode-current characteristic, and the distortion will be greatest when the load impedance is very large. It also causes crosstalk when the valve is used to amplify several channels simultaneously; and it reduces the completeness of rectification in anode-bend detectors and can very materially reduce the detector output. Similarly a low μ at a very high grid bias reduces the efficiency of oscillator valves by allowing a small residual of anode current to flow when the anode voltage is high.

INSULATING MATERIAL FOR HEATER-TYPE VALVES: PURE MAGNESIA.—J. E. Smith. (*Rad. Engineering*, April, 1930, Vol. 10, p. 48.)

"After trying no end of insulating materials and ceramics, pure magnesia in pulverized form, extruded from dies in the desired cross section, broken to proper length, and then fired at a high temperature to rock-hard consistency, is apparently the solution."

COLD CATHODE VALVES. (*Rad., B., F. f. Alle*, Aug., 1930, pp. 338–339.)

Preliminary announcement of two different types exhibited at the German Radio Exhibition. The one uses the glow discharge already well-known in the glow-discharge rectifier; in this type the power saved in filament heating must be supplied in extra anode power to overcome the large cathode-drop. The other type depends on photoelectric emission; it is said that the light from a 2 v. pocket lamp is sufficient. Such a valve would be very useful for high-amplification mains-driven sets, where it is difficult to smooth the mains sufficiently for the filament supply of ordinary valves.

DER TELEFUNKEN-STAB, EINE NEUE RADIORÖHRE (The Telefunken "Rod" Valve [with External Grid]).—Telefunken Co. (*Rad., B., F. f. Alle*, Aug. and Sept., 1930, pp. 371–372 and 387–388; *Die Sendung*, 22nd Aug., 1930, p. 526.)

A flat glass tube about the size of a finger. Inside are the filament and anode only, the grid being represented by a metal coating on the outside of the glass. The price suggested is no dearer than that of a 25 w. incandescent lamp. One special object of the design is for very cheap mains-driven sets; "it requires no grid bias and can be used with the grid directly applied to the preceding anode." It is insensitive to mains hum; apparently its amplification at 50 cycles/sec. is of the order of one-hundredth of that at 1,000 cycles/sec. "On the allied question as to how it behaves to the low speech frequencies which have to be amplified, the company at present has said nothing" [but *cf. Wireless World*, 10th Sept., p. 244].

A REVOLVING-GRID VALVE.—A. B. Du Mont. (*Rad. Engineering*, July, 1930, Vol. 10, p. 24.)

A paragraph on a paper by Du Mont (De Forest Co.) recently read before the Radio Club of America. The grid may be revolved by electronic bombardment or by external electromagnetic influence. Suggested uses include the conversion of a.c. into d.c.; of d.c. into a.c.; the providing of any frequency and almost any wave-form; to replace the oscillating valve as a transmitter; "as a radiovisor of the simplest kind entirely sealed in a single glass bulb."

THE PENTODE AND POWER OUTPUT.—E. Yeoman Robinson. (*Wireless World*, 23rd July, 1930, Vol. 27, pp. 79–82.)

Owing to the peculiar characteristics of the pentode, the calculation of suitable speaker impedance and the available undistorted output is not susceptible to the same treatment as that of a triode. Often the distortion due to the third harmonic is greater than that of the second. In this article the method of measuring distortion is described and it is shown how by the use of a milliammeter the presence of the second and third harmonic components may be detected and prevented.

VACUUM TUBES NOW TURNED OUT WITH PRECISION, AT HIGH SPEED: ONE GRID EVERY FOUR SECONDS—ONE THOUSAND STEMS PER HOUR. MODERN RADIO TUBE MANUFACTURE.—A. E. Lyle. Foster Clark. (*Rad. Engineering*, July, 1930, Vol. 10, pp. 38–39; May, 1930, Vol. 10, pp. 26–27.)

HIGH-SPEED AUTOMATIC TUBE MANUFACTURE: TUBES NOW "PULLED" FROM ATMOSPHERIC PRESSURE TO THE REQUIRED HIGH-VACUUM STATE IN 20 SECONDS.—R. M. Zimber and A. B. Du Mont. (*Rad. Engineering*, April, 1930, Vol. 10, pp. 31–33 and 48.)

GRID GLOW TUBE RELAYS.—Knowles and Sashoff. (*See* under "Subsidiary Apparatus.")

DENSITY DISTRIBUTION OF ELECTRON GAS IN EQUILIBRIUM WITH A HOT BODY.—A. T. Waterman. (*Phys. Review*, 15th March, 1930, Series 2, Vol. 35, No. 6, pp. 668–669.)

Abstract only. "The variation of potential and of electron concentration with distance from a plane emitting surface is investigated. . . . Solutions are found for the equilibrium condition in the absence of applied fields and for negative fields, and assuming the electron gas within the body to be degenerate or classical. Results indicate: (1) that on the average an electron is closer to its neighbors than to the surface, except when very close to the latter, and therefore that the image force explanation of the work function is here not applicable; (2) that space charge is quite competent to give the magnitude of the work function; (3) that if the electron concentration within the body is that of the atoms, the external gas remains degenerate to approximately 10^{-7} cm. from the surface; (4) that an applied negative field of the magnitude required for cold field currents materially alters the electron concentration down into the degenerate region. The current obtainable under retarding fields is discussed with a view to estimating the feasibility of experimental proof of the relations established and of the electron concentration within conductors." *Cf.* Bartlett, below.

A Space Charge Interpretation of Thermionic Work Function.—R. S. Bartlett. (*Phys. Review*, 15th March, 1930, Series 2, Vol. 35, No. 6, p. 669.)

Abstract only of paper read before the American Physical Society, February, 1930. "We try to account for the thermionic work function by the space charge field of electrons streaming out from the surface and turning back in this same field. To account for the increase in thermionic currents in strong electric fields it is necessary that the work function field extend so far out that an escaping electron is much nearer to its neighbours than to the surface. If we extend Fry's space charge analysis, with classical velocity distribution, right down to the surface of the metal, assuming an electron concentration about midway in the range of prediction, we find something resembling saturation currents, a suitable value for the work function, and an increase of current with strong fields agreeing better with experiment (*Proc. Roy. Soc.* A 121, 456, 1928) than does Schottky's expression depending on image force alone. A first order correction for Fermi-Dirac distribution brings improvement, though the variation of work function with temperature is too great. But the strict application of the Fermi-Dirac statistics for a degenerate gas, with its large zero point energy, should remove that difficulty, and should provide for an explanation of field currents, since the large fields necessary should penetrate into the region of degeneracy." *Cf.* Waterman, above.

The Ion-grid Theory of the Decrease in Work Function for Composite Surfaces.—J. A. Becker. (*Phys. Review*, 1st June, 1930, Series 2, Vol. 35, No. 11, p. 1431.)

Abstract only of paper read before the American Physical Society, April, 1930.

Shot Effect of the Emission from Oxide Cathodes.—H. N. Kozanowski. (*Phys. Review*, 1st June, 1930, Series 2, Vol. 35, No. 11, p. 1430.)

Abstract only.

The Chemistry of the Vacuum Tube.—P. G. Weiller. (*Rad. Engineering*, April, 1930, Vol. 10, pp. 34–35 and 48.)

"The chemical as distinguished from the mathematical treatment of electron emission."

Effect of Adsorbed Thorium on the Thermionic Emission from Tungsten.—W. H. Brittain. (*Phys. Review*, 1st June, 1930, Series 2, Vol. 35, No. 11, p. 1431.)

Abstract only of paper read before the American Physical Society, April, 1930.

Messungen von Kontaktpotentialen einiger Metalle (Measurements of the Contact Potentials of Certain Metals).—M. Forró and E. Patai. (*Zeitschr. f. Phys.*, 28th July, 1930, Vol. 63, No. 7/8, pp. 444–457.)

Using a special three-electrode valve and plotting the characteristic first when the grid consists of one simple metal and again when it is coated with a second metal, the writers have determined the contact potentials between sodium and Mo, Pt, Ni, Cu and Fe, and between Mo and Hg. The results agree well with the values for the [differences of the] work functions found by thermionic and photo-electric methods (*cf.* Sixtus, March Abstracts, p. 160, who found the contact potential of tungsten and thoriated tungsten to be 10% smaller than the difference of work functions). An extension of the method allows the independence of temperature of contact potential to be demonstrated. The method, owing to the reproducibility and high accuracy of its results, is suitable for testing the Einstein equation. *Cf.* Lange, 1928 Abstracts, pp. 520–521.

Effect of Positive Ion Shot Effect on Space Charge Limited Electric Currents.—L. P. Smith. (*Phys. Review*, 1st June, 1930, Series 2, Vol. 35, No. 11, p. 1430.)

Abstract only.

Phenomena in Oxide Coated Filaments.—E. F. Lowry. (*Phys. Review*, 15th March, 1930, Series 2, Vol. 35, No. 6, p. 668.)

Abstract only of paper read before the American Physical Society, February, 1930. Experiments are described which tend to support the view that the source of electron emission is a layer of metallic barium occluded on the surface of the core metal, the peculiar effects met with being due to the diffusion of the electrons through the pores of the oxide coating. *Cf.* September Abstracts, pp. 510, same author, and pp. 510–511, Gehrts.

Anwendung der verallgemeinerten Statistik auf thermische Ionisation (The Application of [Kar-Mazundar] Generalised Statistics to Thermal Ionisation).—K. C. Kar and A. Ganguli. (*Zeitschr. f. Phys.*, 18th June, 1930, Vol. 62, No. 7/8, pp. 510–517.)

DIRECTIONAL WIRELESS.

Recent Developments in Direction-Finding Apparatus.—R. H. Barfield. (*Journ. I.E.E.*, Aug., 1930, Vol. 68, pp. 1052–1069; Discussion, pp. 1069–1075.)

The full paper, a summary of which was dealt with in July Abstracts, pp. 397–398.

Eclipse Observations on D.F. at Poulo Condore.—Galle. (*See* under "Propagation of Waves.")

Le Guidage par Câble et le Guidage sans Câble des Navires et des Avions (The Guiding by Cable and without Cable of Ships and Aircraft).—C. Bourgonnier. (*Rev. Gén. de l'Élec.*, 5th July, 1930, Vol. 28, pp. 19–31.)

The first part deals with the Loth leader cables: the second covers much of the ground already covered in the *L'Onde Élec.* paper dealt with in April Abstracts, p. 217.

LANDING INDICATOR FOR AIRPLANES.—E. C. Hanson. (*Rad. Engineering*, April, 1930, Vol. 10, pp. 47 and 49.)

A combination of direction-indicating by electromagnetic induction from cables (*cf.* January and February Abstracts, pp. 47 and 104) with altitude-indicating by a meter which indicates the intensity of the induction received from a loop of buried (sometimes elevated) cable several thousand feet long and 600 feet wide. The system has been tried out extensively at the Ford airport in Illinois.

INFRA-RED BEACON FOR AIRCRAFT.—Physik. Tech. Reichsanstalt. (*E.T.Z.*, 21st Aug., 1930, Vol. 51, p. 1213.)

In a summary of an article in *Zeit. Instrumentenk.*, Vol. 50, pp. 246, 308 and 341, on the 1929 activities of the State Research Establishment, this beacon is briefly described. An a.c. from a small generator is sent through a Case "Thalofide" cell (thallium-sulphur-oxygen combination). During each positive half-cycle of the a.c., a mirror coupled to the generator directs the field of view of the cell towards one section of the earth's surface, while during each negative half-cycle it directs it towards a neighbouring section. The current through the cell, after amplification, passes through a d.c. indicating instrument. If, from one of the two sections thus automatically scanned, a beam of infra-red radiation is being sent out, the indicating instrument will give a direct reading of direction. By a cross-combination of two such devices, altitude as well can be found.

AERONAUTIC RADIOBEACON IMPROVEMENTS: NIGHT ERRORS.—U.S. Bureau of Standards. (*Tech. News Bull.*, Bur. of Stds., May, 1930, No. 157, pp. 43–44.)

In this note on radio-beacon improvements (*see* September Abstracts, p. 512) it is mentioned that during a night flight of 115 miles and back no course variations were observed, though previous *ground* tests at 105 miles had indicated perceptible night variations. Ground tests at 200 miles gave large variations which might seriously limit the usefulness of the beacon at this distance. The results of the above night flight appear to show that the variations in the air are less than ground tests indicate.

THE CAUSE OF ERRORS IN GONIOMETRY WHEN BEARINGS OF RELATIVELY CLOSE LOOP TRANSMITTERS ARE BEING ASCERTAINED.—W. H. Murphy. (*Journ. Maryland Acad. Sci.*, Jan., 1930, Vol. 1, pp. 46–52.)

Tests with direction-finders in aircraft, on 1,000 m. wave transmission from beacon loop transmitters, showed some years ago that as the aircraft approached the beacon deviations were produced due to causes usually neglected but capable of producing serious errors at distances up to six miles. These tests have now been repeated with 71 m. waves: the results were identical and bearing errors up to 90° were found.

The writer's mathematical examination of the radiation and induction components of the fields of a loop transmitter, and of their planes of polarisation, shows the reasons for such errors, and leads to the conclusion that difficulty in locating large or small loop transmitters is bound to occur except at distances greater than five or six wavelengths.

A TUNED-REED COURSE INDICATOR FOR THE FOUR- and TWELVE-COURSE AIRCRAFT RADIO RANGE.—F. W. Dunmore. (*Proc. Inst. Rad. Eng.*, June, 1930, Vol. 18, pp. 963–982.)

See July Abstracts, p. 398.

A 12-COURSE RADIO RANGE FOR GUIDING AIRCRAFT WITH TUNED-REED VISUAL INDICATION.—H. Diamond and F. G. Kear. (*Proc. Inst. Rad. Eng.*, June, 1930, Vol. 18, pp. 939–962.)

See July Abstracts, p. 398.

ACOUSTICS AND AUDIO-FREQUENCIES.

THE ACCURATE MEASUREMENT OF ARTICULATION.—J. Collard. (*P.O. Elec. Eng. Journ.*, April, 1930, Vol. 23, Part 1, pp. 25–35.)

Two previous papers by the writer have dealt with the theoretical side of the work (*Elec. Communic.*, Jan., 1929 and Jan., 1930; see 1929 Abstracts, p. 155, and July Abstracts, p. 401); the present paper is concerned chiefly with its practical application to the development of a technique for the accurate measurement of articulation. This technique includes a novel method of calibrating the articulation crew and the determination of the "ideal sound articulation," based on the experimentally established fact that the average probability of a characteristic band being received correctly over an ideal circuit *is a constant for a given crew*. These methods remove one of the chief objections to articulation testing—that results obtained at different times or by different crews are not comparable. The accuracy obtainable is such that the average error does not exceed $\pm 1.5\%$ for the worst case and for normal circuits is less than $\pm 1\%$.

UN NOUVEAU DISPOSITIF DE MESURES EN COURANT ALTERNATIF MUSICAL: LE POTENTIOMÈTRE-PHASEMÈTRE: APPLICATIONS À LA PHONOMÉTRIE (A New Arrangement for Measurements in Musical Alternating Current: the Potentiometer-Phasemeter: Applications to Acoustic Measurements).——. Nandillon. (*Bull. d. l. Soc. franç. d. Élec.*, July, 1930, Vol. 10, pp. 776–797.)

The potentiometer-phasemeter consists essentially of a potentiometer and a phasemeter connected in parallel, with an auxiliary potentiometer which compensates for the upsetting of the phasemeter circuits when the adjustment of the main potentiometer is unsymmetrical.

The potentiometer and the phasemeter circuits are subjected simultaneously to the vector under examination and the known vector with which it is being compared, and are adjusted to give a zero in a current detector (*e.g.* telephone) in the diagonal connection of the bridge circuit formed by the two circuits. The writer shows how the apparatus can be used for impedance measurements,

for measuring accurately the distortion of the primary and secondary current vectors in a transformer, the effective transformation ratio, etc.; the study of the vibrating state of a solid body, the measurement of the acoustic coefficient of reflection of a substance, and the study of the spectrum of an acoustic instrument.

[CARBON] CONTACT RESISTANCE AND MICROPHONIC ACTION.—F. S. Goucher. (*Phys. Review*, 1st June, 1930, Series 2, Vol. 35, No. 11, pp. 1429–1430.)

Abstract only. An experimental study of single contacts between granules of microphone carbon, the contact forces being of the order of 1 dyne.

BERTRÄGE ZUR KLÄRUNG DER MIKROPHONSCHWINGUNGEN (Contributions to the Elucidation of [Carbon] Microphone Oscillations).—O. Lohaus. (*E.N.T.*, May, 1930, Vol. 7, No. 5, pp. 210–212.)

Author's summary:—An explanation is found and tested experimentally for the microphone oscillations discovered by G. Schubert. The chief condition for the occurrence of the oscillations is that the membrane should expand outwards with increase of temperature. As the voltage across the terminals increases, sparking takes place between the particles of carbon, which are thus welded together into a framework; this breaks down when the membrane resumes its normal form.

THE BEAM MICROPHONE.—(*Science*, 4th July, 1930, Vol. 72, pp. xii and xiii.)

A beam microphone, "really a searchlight turned backwards and using sound instead of light," is being used for the making of sound films at Hollywood. The metal reflector is about five feet in diameter, with a cylinder of felt around its outer edge.

THE HOME-RECORDING OF BROADCAST RECEPTION, ETC., ON GRAMOPHONE RECORDS.—Literaphon Co., and others. (*Rad., B., F. f. Alle*, May, 1930, pp. 235–236 and 198–199.)

Among the disc-materials discussed are "cellesta," a gelatine-like, non-inflammable, unbreakable material; aluminium, zinc, and a special substance which after the record is made is hardened by a liquid. *Cf.* Zache, 1929 Abstracts, p. 638 ("Phonoson" discs).

ELECTROSTATIC LOUD SPEAKER.—(French Pat. 677217, Maché, pub. 5th March, 1930.)

To obtain maximum capacity and maximum amplitude, the mobile electrode is creased into a number of arches which rest against the fixed electrode, or rather against an insulating layer covering this. The greatest air gaps are at the points of junction of the arches, and at these points the fixed electrode is perforated with holes or slots.

FLAT PISTON MOVING COIL LOUD SPEAKERS.—R. W. Paul and B. S. Cohen. (*E.W. & W.E.*, Aug., 1930, Vol. 7, pp. 421–429.)

A paper describing the evolution of the Paul "balsa wood diaphragm" loud speaker (see Sept. Abstracts, p. 513). Balsa wood was chosen for its high ratio of elasticity to density, giving a sound velocity along the grain of 60×10^4 cms./sec., nearly 20 times the velocity in air and greater than in any other material known to the writers; moreover, it has no particular tendency to warp and it can be rendered impervious to atmospheric moisture. Diameters of 10″ or over were selected because smaller pistons were acoustically deficient around 500 p.p.s. The use of surrounds was found to complicate the characteristic by resonances additional to those of free-edge pistons, and was abandoned; the piston works with a small clearance in a small baffle ring to which the actual baffle may be attached. Observed and calculated frequency characteristics are shown and discussed.

WATCHING THE DIAPHRAGM VIBRATE.—G. F. Dutton. (*Wireless World*, 23rd July, 1930, Vol. 27, pp. 85–86.)

Visual observations of the vibrations of a moving-coil loud speaker diaphragm at "slow motion" by means of intermittent light on the stroboscope principle.

JUSQU'À QUEL POINT LES P.U. PEUVENT-ILS ÊTRE CONSIDÉRÉS COMMES PARFAITS? (How nearly perfect may Pick-Ups be considered?) J. Sar. (*Revista Teleg.*, Buenos Ayres, Nov., 1929, Vol. 18.)

The piezoelectric pick-up, although at present perhaps merely a laboratory curiosity, will no doubt be perfected. The electrostatic principle may be used in two ways: the "charge" method (used by the Western Electric Co. for broadcasting) in which the charged condenser influences the grid of the first amplifier valve, and the method in which the pick-up acts on the tuning of an oscillating circuit or on the passage of a r.f. current. Theoretically and practically, the electrostatic pick-up may be considered perfect by reason of its lack of inertia and the absence of a natural frequency. As regards the more usual electromagnetic type, its various defects are discussed. The writer suggests that the driving motor should, by means of an endless worm gear, control the lateral movements of the pick-up so that the needle would follow the centre of the groove without friction: the weight of the membrane could then be reduced very much without fear of "jumping."

THE INTERPRETATION OF RESPONSE CURVES.—(*Wireless World*, 2nd July, 1930, Vol. 27, p. 6.)

A note in which it is shown that a response curve of a loud speaker or gramophone pick-up gives only a partial indication of the performance. Almost identical curves can be obtained from two different loud speakers when the audible result differs greatly, for the reason that the curve simply serves to indicate the cut-off at each end of the scale and the position of the marked resonance peaks. In the usual methods of taking a response curve, the factor of "attack" does not influence the curve at all.

ÜBER AKUSTISCHE SIEBKETTEN (On Acoustic Filters).—E. Lewy. (*Physik. Zeitschr.*, No. 8, Vol. 31, 1930, pp. 358–359.)

Stewart (*Phys. Review*, 20, p. 528, 1922 and 28, p. 1038, 1926) has built acoustic filters analogous to the electrical ones of K. W. Wagner and Campbell. His theoretical treatment is however unsatisfactory as he replaces both the end walls and the sides of the tube by concentrated complex resistances. The conditions are better represented by giving up the representation of the sides of the tube by concentrated resistances and using instead the equation for propagation of waves in the tube. For each portion an incident and reflected wave is assumed and a system of difference equations is obtained from the conditions at the junctions of the tubes. The general solution represents a wave consisting of an infinite series of terms. A common factor $e^{i\gamma}$ is assumed for the solution in the various parts and, omitting frictional losses, it is found that for $\cos\gamma > 1$ pure damping is obtained (arising from the energy reflection) and for $\cos\gamma < 1$ a pure phase displacement. Thus an infinite number of boundary frequencies arise, *i.e.*, the whole frequency spectrum is divided into an infinite number of transmission and attenuation bands. This result has been proved experimentally; with apparatus of suitable dimensions three attenuation bands were found in the region 0–3,000 cycles/sec.

ÜBER DIE FORTPFLANZUNG DES SCHALLES IN ROHREN (On the Propagation of Sound in Tubes).—H. Tischner. (*E.N.T.*, May, 1930, Vol. 7, No. 5, pp. 192–202.)

Author's summary:—A description is given of an acoustical measuring apparatus with which phenomena in tubes can be investigated. A general confirmation of Kirchhoff's theory results from the experiments.

THE STRING AS RESONATOR AND GENERATOR OF ELECTRICAL OSCILLATIONS.—H. Braude. (*Journ. Applied Phys.*, Moscow, No. 6, Vol. 6, 1929, pp. 104–121.)

Investigation of the behaviour of a stretched string lying in a constant magnetic field and traversed by an a.c. A circuit is given which allows self-sustained oscillation; the conditions for this are determined and confirmed by experiment. Such a circuit can be arranged so that the retroaction (dependent on the ohmic resistance of the string) may be adjusted to allow self-sustained oscillation in an extremely weak field. Practical applications are mentioned:—the stabilising of a valve oscillator at acoustic frequencies: the acoustic methods of testing materials: the measurement of magnetic fields—by a method based on the dependence of the effective resistance of the string on the strength of the field.

ZUR DYNAMIK DER SAITEN UND SEILE (The Dynamics of Strings and Wires).—H. Schmidt. (*Zeitschr. f. Phys.*, 25th June, 1930, Vol. 62, No. 9/10, pp. 696–711.)

THE ANALYSIS OF SOUND BY TELEVISION.—Winckel. (*See* under "Phototelegraphy and Television.")

THE PARIS "THEATROPHONE" SERVICE.— —. Testavin. (*Ann. des P.T.T.*, Jan., 1930, Vol. 19, pp. 1–24.)

MUSICAL OSCILLATOR.—R. Raven-Hart. (*Wireless World*, 16th July, 1930, Vol. 27, pp. 58–59.)

An illustrated description of the Martenot, named after its inventor. Like practically all the modern "wireless-music" instruments, the Martenot uses the heterodyne note produced between two oscillators. By means of a switch, variable resistance and filter circuits in the output, three grades of "attack" are possible allowing for detached or staccato playing as well as legato. The natural timbre is very pure, but harmonics can be added at will by the use of filter circuits.

APPLICATION DU COURANT ÉLECTRIQUE, DES OSCILLATIONS RADIOÉLECTRIQUES ET DES PHÉNOMÈNES PHOTOÉLECTRIQUES À LA RÉALISATION DES INSTRUMENTS DE MUSIQUE (Application of the Electric Current, Radioelectric Oscillations and Photoelectric Phenomena, to the Construction of Musical Instruments).— —. Jullien. (*La Vie tech. et indust.*, Jan. and Feb., 1930, pp. 1011–1016 and 1093–1097.)

THE MAGER ELECTRIC ORGAN.—(*Rad., B., F. f. Alle*, Sept., 1930, pp. 388–389.)

The writer considers that this organ, which resembles a small "home" organ in size and a large church or concert instrument in results, will long outlive such apparatus as the "Theremin" or "Martenot." Details are given of the properties of the latest model of the Mager organ.

ELECTRICAL MUSICAL INSTRUMENTS.—F. Trautwein. (*ibid.*, pp. 389–392.)

An article based on Trautwein's work on the imitation of the timbre of various instruments by electrical means, leading to the design of his "Trautonium."

THE "MARTENOT": A NEW RADIO-ELECTRIC MUSICAL INSTRUMENT.—J. Reyval: M. Martenot. (*Rev. Gén. de l'Élec.*, 14th June, 1930, Vol. 27, pp. 945–947.)

THÉORIE D'UN NOUVEAU SYSTÈME D'AMPLIFICATION À BASSE FRÉQUENCE (Theory of a New System of L.F. Amplification).—P. Olinet. (*QST Franç.*, May, 1930, Vol. 11, pp. 30–35.)

The writer reviews the various systems of intervalve coupling for l.f. amplification—transformer, resistance, and impedance coupling, with their various advantages and disadvantages: the first gives a good gain, but the presence of plate d.c. in the primary has several serious disadvantages; the second has the advantage of fidelity but gives only a low gain and becomes less and less attractive as l.f. valves become better and better; the third gives a slightly better gain but introduces a certain amount of distortion.

He then describes his own new arrangement, which is a combination of an autotransformer and a resistance, linked by a condenser; the resistance

may be smaller than in the resistance-coupling method, since the transformer provides a certain amount of gain; the plate d.c. passes through no winding of any sort. "Results are absolutely remarkable," both in gain and in fidelity. The use of an autotransformer suppresses the capacity coupling which always exists between the windings of an ordinary transformer; the transmission of bass frequencies can be improved by increasing the capacity of the linking condenser; the writer also adds an inductance in series with this, "which gives a remarkable means of improving the action of a transformer which has a correct ratio without having enough primary inductance to assure a good transmission of the bass frequencies."

CAUSES AND PREVENTION OF DISTORTION WITH PENTODES.—Yeoman Robinson. (*See* abstract under "Valves.")

WELCHE ELEKTRISCHE ENERGIE MUSS DER VERSTÄRKER AN DEN LAUTSPRECHER ABGEBEN (How Much Electrical Energy must the Amplifier deliver to the Loud Speaker?)—A. Forstmann. (*Die Sendung*, 2nd May, 1930, Vol. 7, pp. 290–291.)

The writer arrives at the following estimates for the maximum energy required by a loud speaker in an average room of 60 cubic metres:—electromagnetic cone type 0.66 w.; electrostatic 1.0 w.; moving coil 2.0 w. He estimates the available a.c. output from a power valve to vary from 10 to 20% of the anode carrying capacity, so that the necessary values for the latter, for the above types of loud speaker, are given as 4.4, 6.66, and 13.33 w. respectively.

ON BANKS OF PARALLELED VALVES FEEDING REACTIVE LOADS WITHOUT DISTORTING THE WAVE-FORM.—Baggally. (*See* under "Properties of Circuits.")

EFFECT OF REVERBERATION TIME IN THE REPRODUCTION OF SOUNDS.—E. A. Johnson. (*Journ. Math. Phys.*, Massach. Inst. of Tech., Feb., 1930, Vol. 9, pp. 1–10.)

From a consideration of the acoustic constants of the room in which the sounds originate and of that in which it is reproduced, the apparent reverberation time in the latter is determined in terms of the reverberation times for the two rooms. It is concluded that by using the analysis given, it is possible to design studios and recording-rooms to meet any conditions of reproduction.

PROBLEMS SUGGESTED BY AN UNCERTAINTY PRINCIPLE IN ACOUSTICS.—G. W. Stewart. (*Phys. Review*, 1st June, 1930, Series 2, Vol. 35, No. 11, p. 1441.)

Abstract only of paper read before the American Physical Society, April, 1930.

METHODS OF ACOUSTIC INTERFEROMETRY FOR THE MEASUREMENT OF VELOCITY AND ABSORPTION OF SOUND IN GASES.—J. C. Hubbard. (*Phys. Review*, 1st June, 1930, Series 2, Vol. 35, No. 11, pp. 1442–1443.)

Abstract only of paper read before the American Physical Society, April, 1930. An application of the method of forced piezoelectric vibrations used in the sonic interferometer.

PHOTOTELEGRAPHY AND TELEVISION.

PHOTOTELEGRAPHY: PICTURE TELEGRAPHY, SIEMENS-KAROLUS-TELEFUNKEN SYSTEM.—E. S. Ritter: G. E. Carr. (*P.O. Elec. Eng. Journ.*, April, 1930, Vol. 23, Part 1, pp. 1–8: July, Vol 23, Part 2, pp. 97–104.)

Papers on the P.O. installation at the G.P.O. (West), London, for the service to Berlin, Frankfort and Copenhagen and capable of extension to Vienna and Stockholm should the demand arise; it is also used for a private service to a news-agency in Paris. Both papers give a number of specimen pictures; some in the second paper illustrate the possibilities of the service as a rival to hand and machine telegraphs. Apart from this, the second paper deals exclusively with the photographic equipment and methods.

THE STATISTICAL PRINCIPLE IN FACSIMILE TELEGRAPHY.—Schröter. (*See* abstract under "Stations, Design and Operation.")

A REVOLVING-GRID VALVE AS TELEVISOR.—Du Mont. (*See* under "Valves.")

DER FERNSEHSENDER DES REICHSPOSTZENTRALAMTES IN WITZLEBEN (The Television Transmitter of the German Post Office in Witzleben).—(*Die Sendung*, 15th Aug., 1930, Vol. 7, pp. 514–515.)

DAS FERNSEHBILD AUF DER GRAMMOFONPLATTE (Television Pictures on Gramophone Discs).—J. L. Baird. (*Die Sendung*, 18th July, 1930, Vol. 7, p. 457.)

A paragraph on the Baird picture-gramophone, in which the television signals are recorded as sounds on a gramophone record, transformed into electric impulses by a pick-up, and after amplification act on a glow lamp, in the interior of the instrument, which is viewed through a Nipkow disc placed under the record and projecting beyond the edge of the latter.

DAS FERNSEHSYSTEM DES BARON CODELLI (The Codelli System of Television [with Spiral Scanning]).——. Codelli. (*Die Sendung*, 14th March, 1930, Vol. 7, p. 187.)

A paragraph, with illustrations, on this system which uses a spiral form of scanning, starting from the outer edge and working inwards to the centre. The turns of the spiral are spaced more closely towards the centre than at the edges, with the result that the picture gives the impression of greater detail than would be expected from the number of elements used—since the eye rests more on the middle portions and the most important action generally occurs there.

The spiral scanning is obtained in a simple way by a ring-shaped mirror supported by a spring and set into vibration by a rotating magnetic field. "Although the new system has certain advantages over the older systems, it also has some disadvan-

tages. It is therefore impossible to say at present whether and how far it will find practical application."

For another system of spiral scanning, using asynchronous prisms, *see* Westinghouse patent, February Abstracts, p. 109.

THE PART PLAYED BY RUSSIAN WORKERS IN THE DEVELOPMENT OF TELEVISION.—B. L. ROSING. (*Elektritchestvo*, Sp. Number, May, 1930, pp. 47–57.)

TWO-WAY TELEVISION.—Ives, Stoller, Blattner and others. (*Journ. Am. I.E.E.*, August, 1930, Vol. 49, pp. 682–684.)

Abridgment of a paper on the "Ikonophone" demonstration referred to in July Abstracts, pp. 401 and 402. With the 72-hole scanning disc employed rotating at 18 r.p.s., the component frequencies of the image signal range from 10 to 40,000 cycles/sec.

DER UNIVERSAL-FERNSEHEMPFÄNGER SYSTEM FRIES (The "Universal" Television Receiver, Fries' System).—F. Noack. (*Rad., B., F. f. Alle*, Aug., 1930, pp. 360–365.)

Illustrated description of this receiver, which is designed to receive at will, without change, either the German or English television transmissions with their differing modes of scanning and shapes of picture. A more complex system is also being developed which will apply to still more types of transmission when these are available for reception.

THE BAIRD RECEIVING SCREEN.—(*Engineer*, 1st Aug., 1930, Vol. 150, p. 121.)

Paragraph on the television receiving screen recently demonstrated at the London "Coliseum." It is divided into 2,100 elements, each containing a small metal filament lamp. *See Television*, Aug., 1930, Vol. 3, pp. 255–256, and *Wireless World*, 9th July, p. 39.

THE ANALYSIS OF SOUND BY TELEVISION.—F. W. Winckel. (*Die Sendung*, 11th April, 1930, Vol. 7, p. 253.)

If music is received on a television receiver, a great variety of figures is obtained, depending on the character of the music. Examples given here include records of soprano and baritone voices, each with piano accompaniment, of a violin solo and of an orchestra.

FIRE DIRECTION BY TELEVISION.— —. Routin. (*Génie Civil*, 16th Aug., 1930, Vol. 97, pp. 159–160.)

In an article here summarised, on the Schneider "Strobonéon" distant indicator system for fire direction, particularly on battleships, the writer says that tests in progress indicate that in the near future distant direction will be by radio waves, since the luminous system used in the Strobonéon is really only a form of television. It is a combination of the stroboscopic principle and the neon lamp.

STANDARD TIME BY TELEVISION.—(*Die Sendung*, 18th July, 1930, Vol. 7, p. 457.)

A paragraph on the suggestion that a wireless high-power station should continuously transmit the picture of the face of a standard chronometer showing Greenwich time.

AMPLIFYING THE OUTPUT OF PHOTO-ELECTRIC CELLS.—E. H. Vedder. (*Electric Journ.*, May, 1930, Vol. 27, pp. 280–283.)

The three general types of multi-stage amplifier (resistance, capacity, and transformer coupling) are described and their circuits given. The use of the grid-glow relay tube as an amplifier is considered; the paper concludes with a discussion of the main types of light-source units used with photoelectric cells.

LES AMPLIFICATEURS POUR CELLULES PHOTO-ÉLECTRIQUES (Amplifiers for Photoelectric Cells).—E. H. Vedder. (*Elec. Journal*, April, 1930, Vol. 27, pp. 224–227.)

Deals with the use, and the comparative advantages and disadvantages, of valve amplifiers and grid-glow relay tubes.

REPRODUCTION AND AMPLIFICATION IN TELEVISION RECEIVERS.—F. Schröter. (*Television*, April, June, July, Aug., 1930, Vol. 3.) *See* February Abstracts, p. 107.

The paper deals at considerable length with the phenomena and laws of co-ordinate distortion. In the August issue the writer gives his conclusions as to the superiority of vertical scanning over horizontal (*see* April Abstracts, p. 220, right hand column). For corrections of typographical errors, *see* May issue, p. 147.

PHOTOELECTRIC PROPERTIES OF EXTREMELY THIN FILMS OF ALKALI METALS.—H. E. Ives and H. B. Briggs. (*Phys. Review*, 15th March, 1930, Series 2, Vol. 35, No. 6, p. 669.)

Abstract only of paper read before the American Physical Society, February, 1930. "Films of alkali metal much thinner than those previously studied (Astrophys. J. 60, 209, 1924) have been investigated by using an electrometer of approximately 100 times the sensitiveness of the galvanometer used before. Attention has been directed to the variation of emission with the angle of incidence and plane of polarisation of the exciting light. In agreement with the earlier work, the ratio of emissions for obliquely incident light polarised with the electric vector in and perpendicular to the plane of incidence decreases as the film is reduced in thickness. The new measurements show further that this ratio continues to decrease with film thickness to the value unity, where no variation of emission with angle occurs, and that with further decrease in film thickness, the relationship *reverses* ("normal" greater than "selective") and the emission increases with the angle of incidence of the light. It is suggested that when the alkali metal particles become sparsely distributed their absorption of light corresponds to that of a matt surface (Lambert's law). When the particles are still more widely separated, deviation from Lam-

bert's law occurs and the exciting light is in part that reflected from the underlying platinum surface, stronger for light polarized with the electric vector parallel to the surface."

EINE NEUE PHOTOZELLE (A New Photoelectric Cell). —H. von Hartel: B. Lange. (*Rad., B., F. f. Alle*, Aug., 1930, pp. 359–360.)

An enthusiastic article by the first-named on the semi-conductor cell developed by the second-named (*see* May and June Abstracts, pp. 283 and 342).

THE CÄSOPRESS PHOTOELECTRIC CELL.—(*Die Sendung*, 22nd August, 1930, Vol 7, p. 526.)

In an article on the Berlin Exhibition this new cell is mentioned, which has its maximum sensitivity in the orange part of the spectrum and is thus suitable for the scanning of films by incandescent electric light.

A POSSIBLE EXPLANATION OF THE SELECTIVE PHOTOELECTRIC EFFECT.—R. H. Fowler. (*Proc. Roy. Soc.*, July, 1930, Series A, Vol. 128, No. 807, pp. 123–130.)

ÜBER DEN EINFLUSS VON STICKOXYD AUF DIE LICHTELEKTRISCHE EMPFINDLICHKEIT DES KALIUMS (The Influence of NO on the Photoelectric Sensitivity of Potassium).—R. Fleischer and H. Teichmann. (*Zeitschr. f. Phys.*, 19th Feb., 1930, Vol. 60, No. 5/6, pp. 317–319.)

The presence of NO increases the sensitivity very greatly (perhaps by its reducing action) with a sharp maximum round 365 mμ; thus forming a basis for the design of a cell with very high sensitivity for ultra-violet light.

PHOTO-LUMINESCENCE: FLUORESCENCE, PHOSPHORESCENCE.—L. Chalkley, Jr. (*Trans. Am. Illum. Eng. Soc.*, Feb., 1930, Vol. 25, pp. 172–183.)

A general description, leading to methods of preparation and use of luminescent materials.

ÜBER DEN INNEREN PHOTOEFFEKT IN KRISTALLINEN HALBLEITERN (On the Internal Photoelectric Effect in Crystalline Semi-Conductors).—I. Runge and R. Sewig. (*Zeitschr. f. Phys.*, 3rd July, 1930, Vol. 62, No. 11/12, pp. 726–729.)

The current in a thallium cell is a photoelectric secondary current, according to the definition of Gudden and Pohl. The presence of a primary current, smaller in value and strictly proportional to the absorbed energy, free from lag and subject to a saturation value depending on the applied potential, is assumed (though it has not been separated). Each primary electron set free by the light causes a disturbance of the lattice, which becomes settled after a time regulated by the laws of probability. The conductivity of the photoelectric layer is proportional to the number of points of lattice disturbance.

Curves derived mathematically from the above hypotheses agree exceedingly well with those recorded by oscillograph.

DER GALVANISCHE POLARISATIONSEFFEKT DER FESTEN LICHT-EMPFINDLICHEN SELENZELLE (The Galvanic Polarisation Effect in the Solid Light Sensitive Selenium Cell).—D. Reichinstein. (*Naturwiss.*, 25th July, 1930, Vol. 18, No. 30, pp. 685–689.)

An account of experiments proving the existence of the asymmetrical Bequerel effect.

EFFECTIVE PHOTOELECTRIC WORK FUNCTION REDUCED BY WEAK ACCELERATING FIELDS.—W. B. Nottingham. (*Phys. Review*, 15th March, 1930, Series 2, Vol. 35, No. 6, p. 669.)

Abstract only of paper read before the American Physical Society, February, 1930. *Cf.* August Abstracts, page 460.

PHOTOELECTRIC BEHAVIOUR OF SOLID AND LIQUID MERCURY.—D. Roller. (*Phys. Review*, 1st January, 1930, Series 2, Vol. 35, No. 1, page 122.)

Abstract only of paper read before the American Physical Society, November, 1929.

REDUCTION OF PHOTOELECTRIC CURRENT BY INFRA-RED RAYS.—A. R. Olpin. (*Science*, 27th June, 1930, Vol. 71, p. xiv.)

A paragraph on Olpin's announcement that when a sodium or potassium cell is excited by visible light, the current may be reduced as much as 50 per cent. when infra-red light falls on the cell.

VALIDITY OF EINSTEIN'S PHOTOELECTRIC EQUATION FOR RED SENSITIVE SODIUM COMPOUNDS.—A. R. Olpin. (*Phys. Review*, 15th March, 1930, Series 2, Vol. 35, No. 6, p. 670.)

Abstract only.

MEASUREMENTS AND STANDARDS.

BIEGUNGS- UND TRANSVERSALSCHWINGUNGEN PIEZOELEKTRISCH ANGEREGTER QUARTZPLATTEN (Flexural and Transverse Oscillations of Piezoelectrically Excited Quartz Plates).—H. Doerffler: E. Madelung. (*Zeitschr. f. Phys.*, 7th July, 1930, Vol. 63, No. 1/2, pp. 30–53.)

Pure flexural vibrations can be formed, instead of transverse, when λ is large compared with the thickness d; in practice, if $\lambda/d \approx 10$. In such vibrations, only the particles in the middle plane of the plate undergo pure transverse movements, all the others having longitudinal displacements in addition. Whereas the velocity of propagation of transverse waves is constant ($v = \sqrt{F/\rho}$, where F is the torsion modulus and ρ the thickness), the velocity of flexural waves depends on λ and f; for pure waves v varies as $1/\lambda$ and as $\sqrt{f}$.

It is natural to expect that there must be a gradual transition from the flexural to the transverse mode as the ratio λ/d is decreased, this transition being indicated by a change in velocity. The present work deals with the investigation of this transition. It was shown experimentally that the velocity, starting from the value given by $v^2 \sim f$, approaches nearer and nearer to the con-

stant value for transverse waves as the ratio λ/d is decreased. The paper then gives a theoretical analysis of the processes involved, derived by Madelung on elasticity principles. The final equation reached is

$$(1-\sigma/2)^2 \cdot \frac{1}{\sqrt{(1-\sigma)\left(1-\frac{\sigma \cdot A}{A+B}\right)}} = \frac{\tan(\delta \cdot \sqrt{1-\sigma})}{\tan\left(\delta \cdot \sqrt{1-\frac{\sigma \cdot A}{A+B}}\right)},$$

where $\sigma = v_{flex}^2 \cdot \rho/A = \frac{\rho\omega^2}{A \cdot a^2}$, so that $\sqrt{\sigma} = v_{flex}/v_{tr}$; and $\delta = \pi \cdot d/\lambda$. A and B are constants related to the elasticity modulus E and the Poisson contraction number μ by the equations $A = \frac{E}{2(1+\mu)}$ = torsion modulus, and $B = \frac{E}{2(1+\mu)(1-\mu)}$. Since this final equation does not allow a direct calculation of $\sqrt{\sigma}$, and hence of v_{flex}, it must be supplemented by a graphical approximation. Theoretical and experimental results agree very well.

OBSERVATIONS SUR LE QUARTZ (Observations on Quartz).—R. Weil. (*Comptes Rendus*, 4th Aug., 1930, Vol. 191, pp. 270–272.)

A comparison of the crystalline and optical properties of quartz found in different parts of the world.

THE PARAMETERS OF PIEZOELECTRIC RESONATORS.—J. Kobzarew. (*Journ. Applied Phys.*, Moscow, No. 2, Vol. 6, 1929, pp. 17–37.)

The characteristics of a resonator can be defined better by the four constants, dielectric capacity, natural frequency, damping and resonance resistance, than by the parameters of the equivalent circuit, L, C and R. These resonator constants are not independent of each other—the damping and the resonance resistance are interconnected through the crystalline constants and dimensions of the quartz. An approximate mathematical treatment is given leading to formulæ for determining the piezoelectric modulus from electrical measurements of resonance resistance and damping.

For particulars concerning the various methods of measurement investigated, *see* abstract in *Physik. Ber.*, 15th July, 1930, pp. 1462–1463.

ÜBER DIE EIGENSCHAFTEN DER PIEZOELEKTRISCHEN RESONATOREN (On the Properties of Piezoelectric Resonators).—J. Kobzarew. (*Journ. Applied Phys.*, Moscow, No. 6, Vol. 6, 1929, pp. 99–103.)

Among the phenomena resulting from the existence of many natural frequencies crowded into a very small range are the formation of numerous oscillation hysteresis loops and the simultaneous appearance of two oscillations of different frequencies. Two special cases of the appearance of modulated oscillations are described. In one case the carrier frequency was stabilised and approximately equal to the resonator natural frequency; the modulation was of almost constant frequency, but was by no means sinusoidal. In the other case there was a pair of frequencies (sinusoidal modulation), the higher of which was stabilised and equal to the resonator natural frequency, whereas the carrier frequency depended on the parameters of the oscillatory circuit.

MAGNETOSTRICTION MEASUREMENTS USING A HETERODYNE BEAT METHOD.—A. B. Bryan and C. W. Heaps. (*Phys. Review*, 1st Feb., 1930, Series 2, Vol. 35, No. 3, p. 298.)

Abstract only of paper read before the American Physical Society, Dec., 1929.

THE ESTABLISHMENT OF THE JAPANESE RADIO-FREQUENCY STANDARD.—Y. Namba. (*Proc. Inst. Rad. Eng.*, June, 1930, Vol. 18, pp.1017–1027.)

Based on a paper read before the World Engineering Congress in Japan (June Abstracts, p. 342). Author's summary:—This paper describes the standard frequency equipment established at this laboratory. A valve-maintained tuning fork of Elinvar steel, made by H. W. Sullivan Co., Ltd., London, has been taken as the working standard. Some of the important characteristics of its frequency variation have been measured and adjustments have been made in order to minimise the variations which have been observed. The absolute value of its frequency has been measured through a long series of tests and the following value obtained as the mean frequency: 999,770 cycles per sec. at 36.0 deg. Cent.

The precision of measurement is estimated as being well within one part in one million, but, because of the effect of atmospheric pressure, the constancy of maintenance is a few parts in one million. Two stages of multivibrators multiply the standard frequency by one thousand and the calibration can be made with an accuracy of one part in several hundred thousand. In order to determine the constancy of maintenance of the standard, a piezo-electric oscillator has been calibrated from time to time over a period of five months and the results have been satisfactory.

UN APPARECCHIO PER LA TARATURA DEI CIMOMETRI MEDIANTE L'USO DEI PIEZOOSCILLATORI (An Apparatus for the Calibration of Wavemeters by the Use of Piezo Oscillators).—G. Angrisano. (*L'Elettrotec.*, 25th June, 1930, Vol. 17, pp. 420–421.)

Description of a compact apparatus for a range of 85 to 37,500 kc./sec.

FRÉQUENCEMÈTRE DE PRÉCISION S.F.R. (The S.F.R. Precision Frequency Meter). (*Bull. S.F.R.*, May, 1930, Vol. 4, pp. 73–79.)

An industrial instrument to satisfy the recommendations of the C.C.I.R., for wavelengths between 14 and 32 metres, 50 and 100 metres, or other similar range. Five interchangeable inductances are used. The instrument is calibrated with an accuracy of 1 in 10,000 against the Paris National Wireless Laboratory standard.

A MICROVOLT-HOUR METER.—A. F. Dufton. (*Journ. Scient. Instr.*, July, 1930, Vol. 7, pp. 228–229.)

An e.m.f. equal and opposite to the one to be integrated is produced by heating a thermocouple with power from a.c. mains, this power being integrated by an induction meter. A relay looks after the equality of the unknown e.m.f. and the opposing one.

THE POTENTIOMETER-PHASEMETER AND ITS APPLICATIONS.—Nandillon. (*See* abstract under "Acoustics.")

IMPEDANCE MEASUREMENT WITH THE PLIODYNATRON.—P. D. Zottu. (*QST*, July, 1930, Vol. 14, pp. 39–40.)

INDUCTIVE RATIO ARMS IN ALTERNATING CURRENT BRIDGE CIRCUITS.—R. Walsh. (*Phil. Mag.*, July, 1930, Series 7, Vol. 10, No. 62, pp. 49–70.)

In the practice of alternating current measurements with the Wheatstone bridge the chief difficulties which have been encountered in obtaining high accuracy have been concerned with the stray capacities in the circuit and the balance of the ratio arms. This paper gives a theoretical account of a new type of ratio arms assembly intended to give high stability and high accuracy and to render more simple the questions of construction and maintenance. The bridge ratio is determined by reactive impedances, these being in the form of bifilar windings on a single core. The essential points in the production of retard coil ratio arms are the use of a toroidal core and multifilar windings. The material of the core should have high permeability, in order that the direct current resistance of the windings may be as low as possible.

AN IMPROVED FORM OF MAXWELL D.C. INDUCTANCE BRIDGE, AND A METHOD OF MEASURING THE TIME CONSTANT OF THE CORE OF A MAGNET.—L. H. Harris and H. Williams. (*P.O. Elec. Eng. Journ.*, April, 1930, Vol. 23, Part 1, pp. 36–41.)

MESURE DE COURANTS CONTINUS À INTENSITÉS ÉLEVÉES (The Measurement of Very Large Direct Currents).—V.-Arlhac : Pestarini. (*Bull. d.l. Soc. franç. d. Élec.*, June, 1930, Vol. 10, pp. 692–695.)

A paper on the Pestarini method, which avoids the use of shunts by surrounding the bar carrying the current by a magnetic circuit, and annulling the flux produced in this by means of a measured current in a multi-turned winding on this magnetic circuit.

EINE PRÄZISIONSMETHODE ZUR VERGLEICHUNG VON ELEKTROLYTWIDERSTÄNDEN BEI HOCHFREQUENZ (A Precision Method for the Comparison of Electrolyte Resistances at High Frequencies).—A. Deubner. (*Ann. der Physik*, 1930, Ser. 5, Vol. 5, No. 3, pp. 305–324.)

From the author's summary :—"An experimental arrangement is described for the comparison of conductivities of electrolytes at frequencies of 10^7 cycles/sec. with an accuracy of $\pm 0.03\%$, when the solutions are neutral. The method consists in the slight over-compensation of the damping effect of the electrolyte resistance, which is connected in parallel with the condenser of an oscillating circuit, by means of a back-coupled triode. . . .

"The sources of error are discussed in detail. . . . The results of experiments with $CaSO_4$ and HCl solutions are given. . . ."

MESSUNG KLEINER WECHSELSTROMLEISTUNGEN BEI GROSSEN PHASENVERSCHIEBUNGEN (Measurement of Small Amounts of Alternating Current Power in the Case of Large Phase Differences).—W. Spielhagen. (*Arch. f. Elektrot.*, 30th May, 1930, Vol. 23, No. 6, pp. 609–642.)

DIE MESSUNG VON HOHEN WECHSELSPANNUNGEN AUS DEM MAGNETISCHEN FELD DES VERSCHIEBUNGSSTROMS (The Measurement of High Alternating Voltages from the Magnetic Field of the Displacement Current).—H. Lamb. (*Arch. f. Elektrot.*, 30th May, 1930, Vol. 23, No. 6, pp. 643–666.)

AN AMPLIFIER FOR MEASURING SMALL CURRENTS.—R. D. Bennett. (*Review Scient. Instr.* Aug., 1930, Vol. 1, pp. 466–470.)

Author's abstract :—An amplifier is described which uses a four-electrode tube of the ordinary type, and gives maximum current sensitivities of the order of 10^{-18} ampères. A novel feature consists in using as grid leak the positive ion emission of the filament.

SOME DEVELOPMENTS OF THE THERMIONIC VOLTMETER.—E. B. Moullin. (*Journ. I.E.E.*, Aug., 1930, Vol. 68, pp. 1039–1051.)

Author's summary :—In this paper the various ways are considered in which a 3-electrode valve should be used in a thermionic voltmeter, and the accumulated experience is described of several years' work by the author in making valve voltmeters for various purposes. No one arrangement can possess every desirable property, and it is shown how to produce a voltmeter to fulfil specified requirements. The effective input resistance of the various arrangements, and the harmonic currents produced by grid current, are considered analytically and experimentally. The effect on range and sensitivity of providing additional batteries is also discussed, extra batteries being found to be an advantage only in very low-range instruments.

The effect on the calibration of a change in the valve and in temperature is found to depend on the form of the rectifier used. In general, a thermionic voltmeter cannot read r.m.s. values. The waveform error of various systems is investigated ; with one arrangement the reading is proportional to the peak voltage and in another to the mean. The possibility of a frequency error is discussed ; tests show that the error is negligible for frequencies up to 1,000 kilocycles per sec., whilst from indirect

tests it would appear that the error is probably negligible for frequencies up to 30 times this value.

THE UNIT OF TRANSMISSION.—J. Pomey. (*Rev. Gén. de l'Élec.*, 29th March, 1930, Vol. 27, pp. 475–480.)

SUBSIDIARY APPARATUS AND MATERIALS.

REMARQUES SUR LES DERNIERS MULTIPLICATEURS STATIQUES DE HAUTE FRÉQUENCE EMPLOYÉS EN T.S.F. (Remarks on the Latest Static High Frequency Multipliers used in Wireless [Transmitters]).—G. E. Petit: K. Schmidt. (*Bull. d. l. Soc. franç. d. Élec.*, June, 1930, Vol. 10, pp. 667–674.)

In the Schmidt-Dornig (Lorenz) r.f. static multipliers (*cf.* Aug. Abstracts, p. 466, Schmidt) an alternator of frequency about 7,500 cycles/sec. saturates an iron core from whose winding a current of any desired odd harmonic (say the 45th) can be taken; the artifice which makes this possible consists in connecting across the winding terminals an auxiliary shunt circuit (inductance and capacity in series) presenting a small impedance to an odd harmonic intermediate between the alternator frequency and that of the harmonic desired. This shunt circuit can be dispensed with if the total multiplication is carried out in two stages; *i.e.* unless a multiplication of more than say 33 is required.

In the latest models, the iron surrounds the copper as in Krarup cables. As an example of the "ridiculously" small size of multiplier necessary, a 242 m. wave transmitter for 2 kw. in the aerial needs two multipliers each measuring only $8 \times 7 \times 3$ cms., and consisting of 6 turns of copper ribbon, surrounded by annular discs of iron weighing in all less than 100 gms.

The paper gives a mathematical and graphical treatment of the processes involved. For a paper on Schmidt's medium and high frequency alternators, presumably used in conjunction with the above multipliers, see 1929 Abstracts, p. 112.

STABILIZED OSCILLOSCOPE WITH AMPLIFIED STABILIZATION.—F. Bedell and J. G. Kuhn. (*Phys. Review*, 15th March, 1930, Series 2, Vol. 35, No. 6, p. 657.)

Abstract only of paper read before the American Physical Society, February, 1930. *See* July Abstracts, p. 407.

THE TWO-POINT KLYDONOGRAPH FOR MEASUREMENT OF WAVE FRONT.—Someda. (*See* under "Atmospherics.")

DER KLYDONOGRAPH, EIN GERÄT ZUR REGISTRIERUNG VON ÜBERSPANNUNGEN IN HOCHSPANNUNGSNETZEN (The Klydonograph, an Instrument for Registering Surges in H.T. Networks).—F. A. Förster. (*Dinglers Journ.*, No. 4, Vol. 345, 1930, pp. 61–64.)

Description of the Siemens type, which requires only a weekly winding of the clockwork and a change of film.

AMPLIFIER-OSCILLOGRAPH COMBINATIONS. — L. Draub: O. Naumann. (*E.T.Z.*, 10th July, 1930, Vol. 51, p. 1022.)

Correspondence on the subject of compensating for the voltage drop in the first valve anode-circuit resistance produced by the anode d.c. current, in order to work the second valve on a favourable part of its characteristic; also on similar treatment of the oscillograph loop, to free it from the anode current of repose.

RECORDING FAST TRANSIENT PHENOMENA WITH CATHODE RAY OSCILLOGRAPH IN FREE AIR AS WELL AS IN HIGH VACUUM.—M. Knoll. (*Journ. Am. I.E.E.*, June, 1930, Vol. 49, pp. 463–465.)

See Abstracts, June, p. 345, and Sept., p. 520.

EIN BESONDERER TYPUS DES KATHODENOSZILLOGRAPHEN (A Special Type of C. R. Oscillograph).—H. Norinder. (*Zeitschr. f. Phys.*, 2nd Aug., 1930, Vol. 63, No. 9/10, pp. 672–684.)

A long paper, illustrated by photographs and many typical records, on the Norinder instrument referred to in past abstracts (*cf.* Sept. Abstracts, p. 520.)

A VARIABLE BUT CONSTANT SPEED RECORDING DRUM.—D. C. Gall. (*Journ. Scient. Instr.*, July, 1930, Vol. 7, pp. 230–231.)

UNTERSUCHUNG DES HELMHOLTZSCHEN PENDELS MIT DEM KATHODENOSZILLOGRAPHEN (Investigation of the Helmholtz Pendulum with the Cathode Ray Oscillograph).—W. Fucks. (*Arch. f. Elektrot.*, 30th May, 1930, Vol. 23, No. 6, pp. 589–592.)

The Helmholtz pendulum is frequently used for making electrical contacts of short duration (10^{-2} to 10^{-4} sec.). This paper is a short account of its calibration by means of a cathode ray oscillograph and of an investigation of its utility for making very short contacts. It is found that, if the contact is to be very short, the only circuits for which the pendulum can be used are those which it opens, not those closed by it. In this case durations of the order of 3×10^{-3} sec. may be obtained.

PRECISE MEASUREMENT OF SHORT TIME INTERVALS BY USE OF THE MICROCHRONOGRAPHIC WHEEL.—G. R. Town. (*Review Scient. Instr.*, August, 1930, Vol. 1, pp. 449–465.)

Apparatus and methods are described by which time intervals from 20 microseconds to 10 seconds or more may be measured to a precision of 20 microseconds.

A NEW METHOD OF MEASURING SHORT TIME INTERVALS BY MEANS OF A DIRECT READING INSTRUMENT.—W. Phillips. (*Journ. Scient. Instr.*, April, 1930, Vol. 7, pp. 126–128.)

AUTOMATISCHE UEBERWACHUNGSVORRICHTUNGEN ZUR KONTROLLE DES LADE- UND ENTLADEVORGANGES BEI AKKUMULATOREN-BATTER-

IEN (Automatic Controls for Accumulator Battery Charging and Discharging).—W. Janički. (*Bull. Assoc. Suisse d. Élec.*, 22nd June, 1930, Vol. 21, No. 12, pp. 389–396.)

Particular attention is given to the special charge and discharge counters (accumulator-meters) of the firm Landis and Gyr.

THE DRUMM BATTERY—IS IT A REVOLUTION?—R. N. Tweedy: Drumm. (*Elec. Review*, 22nd Aug., 1930, Vol. 107, pp. 290–292.)

A critical examination of the new rapid-charging alkali accumulator referred to in 1929 Abstracts, p. 584.

DIAGRAMME DE FONCTIONNEMENT D'UN TRANSFORMATEUR AUTORÉGULATEUR À ENROULEMENT MOBILE (Working Diagram of a Self-Regulating Transformer with Mobile Winding).—V. Genkin. (*Rev. Gén. de l'Élec.*, 5th July, 1930, Vol. 28, pp. 13–16.)

RELAIS FONCTIONNANT À L'ÉQUILIBRE INDIFFÉRENT (Relays working in Neutral Equilibrium).—H. de Bellescize. (*Rev. Gén. de l'Élec.*, 31st May and 7th June, 1930, Vol. 27, pp. 857–870 and 899–908.)

An exhaustive paper on the particularly simple relay (horse-shoe magnet with springy armature, one end of which is fixed to one pole while the other end moves between adjustable contacts) which the writer employs in his automatic volume control (*see* September Abstracts, p. 509). Such a design is as sensitive as the best pivoted and spiral-spring-biased relays, while "incomparably more rapid and robust . . . It is indeed curious that in 1929 there should remain enough hidden resources in a simple electromagnet to enable it to compete successfully against pieces of apparatus far more complicated and highly specialised." The first part of the paper deals with the constructional side of these relays, while the second part is devoted to a theoretical treatment ending with an example of the calculation of a relay to conform with given conditions.

GRID GLOW TUBE RELAYS.—D. D. Knowles and S. P. Sashoff. (*Phys. Review*, 1st June, 1930, Series 2, Vol. 35, No. 11, p. 1431.)

Abstract only of paper read before the American Physical Society, April, 1930.

PHOTOELECTRIC CELL THERMOREGULATOR.—F. G. Brickwedde and R. B. Scott. (*Phys. Review*, 15th March, 1930, Series 2, Vol. 35, No. 6, p. 670.)

Abstract only of paper read before the American Physical Society, February, 1930. "A photoelectric regulator has been made which will automatically maintain any temperature from 0° to liquid air temperatures constant to 0.001°. It is operated on 240 volt d.c. power, without batteries, using only one slide wire rheostat with four sliding contacts to furnish all the sources of potential for the photoelectric cell and its amplifier, thus making the regulator less expensive and obviating all the inconveniences of run down batteries."

MERCURY VAPOUR RECTIFIERS WITH SPECIAL METHOD OF CONDENSATION AT THE CATHODE.—(French Pat. 680892, Brown Boveri, pub. 7th May, 1930.)

Summary in *Rev. Gén. de l'Élec.*, 28th June, 1930, Vol. 27, p. 223D.

THE JET-WAVE RECTIFIER: THE EXPERIMENTAL AND THEORETICAL BASIS OF ITS DESIGN.—J. Hartmann. (*Journ. I.E.E.*, Aug., 1930, Vol. 68, pp. 945–969: Discussions, pp. 969–988.)

The full paper, a summary of which was referred to in May Abstracts, p. 287.

UNIDIRECTIONAL CONDENSER DISCHARGE FOR PRODUCTION OF D.C. OR SUCCESSIVE PULSES.—Sano. (*See* abstract under "Properties of Circuits.")

GLEICHRICHTUNG SEHR HOHER WECHSELSPANNUNGEN (The Rectification of Very High A.C. Voltages).—E. Marx. (*E.T.Z.*, 31st July, 1930, Vol 51, pp. 1089–1090.)

The writer first explains the failure of previous attempts to use the point-to-plate spark-gap as a practical rectifier for very high voltages. In the AEG method now being patented, the two great difficulties—back-discharge as the point wears blunt and the plate roughens, and the variation of the rectified voltage between zero and its peak value—are overcome. Compared with the hot-cathode and mechanical rectifiers, the arrangement is very simple and very cheap. Several gaps can be connected in series: by this plan, rectified voltages of 800 kv. have been obtained.

MAGNETIC RECTIFIERS WITH AUTOMATIC CONSTANCY OF RECTIFIED VOLTAGE.—(French Pat. 680386, Soc. Leblanc Vickers: Demontvignier, pub. 29th April, 1930.)

The compensating effect of the compounding choke is such that the output from the smoothing filter is at a voltage independent of the load; or the voltage can even rise with increase of load. For a long summary *see Rev. Gén. de l'Élec.*, 28th June, 1930, Vol. 27, p. 222D.

KUPFEROXYDUL-TROCKENGLEICHRICHTER (Copper-Oxide Dry-Plate Rectifiers).—O. Irion. (*E.T.Z.*, 10th July, 1930, Vol. 51, pp. 993–999.)

A survey, the first part of which includes a treatment of the general principles, method of working, influence of temperature and pressure, efficiency, output, and life. The second part deals with various applications: trickle charging, rapid charging: for commerical electro-chemistry: for the production of magnet fields: for measuring instruments and laboratories.

QUELQUES PARTICULARITÉS DES REDRESSEURS MODERNES (Some Details of Modern [Mercury Vapour] Rectifiers).— —. Roy. (*Bull. d. l. Soc. franç. d. Élec.*, July, 1930, Vol. 10, pp. 764–776).

Glass and metal types are dealt with. In the

subsequent discussion, the questions of rubber joints, anodes of graphite, maintenance and cleaning, etc., are examined.

DIE GLEICHSTROMLEISTUNG DES GLÜHKATHODEN-GLEICHRICHTERS. (The D.C. Output of the Hot-Cathode Rectifier). — P. Cornelius. (*E.T.Z.*, 24th July, 1930, Vol. 51, pp. 1067–1068.)

WINDMILL GENERATORS FOR BATTERY CHARGING, ETC.—(*Electrician*, 25th July, 1930, Vol. 105, p. 121.)

A short article on the automatic high speed windmill generators made by Wilkinson and Partners, Ltd., one of which has been supplied to the British Arctic Air Route Expedition for charging their wireless batteries. The generator will provide current in winds as low as 7 m.p.h., and will run day and night through gales of 50 m.p.h. without injury or attention and without the charging rate being greatly exceeded.

MERCURY RELAYS WITH VARIOUS TYPES OF DELAY ACTION.—(French Pat. 680504, Soc. Signum, pub. 1st May, 1930.)

Summary in *Rev. Gén. de l'Élec.*, 28th June, 1930, Vol. 27, pp. 222–223D.

APPAREIL "MADER-OTT" POUR L'ANALYSE DES COURBES PÉRIODIQUES (The Mader-Ott Analyser for Periodic Curves).— —. Heyberger. (*Bull. d. l. Soc. franç. d. Élec.*, August, 1930, Vol. 10, pp. 918–922.)

RESISTANCE, RHEOSTATS AND FUSES.—G. Rebora. (*L'Elettrotec.*, 3rd March, 1930, Vol. 17, pp. 149–158.)

A paper deriving formula and tables for the calculation of these accessories.

SUR LES PILES À CATHODE DE SODIUM (The Sodium Cathode Cell).—G. I. Costeanu. (*Comptes Rendus*, 28th July, 1930, Vol. 191, pp. 205–207.)

More on the subject referred to in 1929 Abstracts, p. 585. The CuO-$CaCl_2$.KCl-NaPb cell gives 2.145 volts on a discharge of 92 mA. for 3 hours, at a temperature of 640°.

METHODEN ZUR FESTSTELLUNG DES ALTERUNGS-GRADES VON TRANSFORMATOREN- UND SCHALTERÖLEN (Methods for Determining the Degree of Ageing in Transformer and Switch Oils).— —. Typke. (*Elektrot. u. Masch:bau*, 2nd Feb., 1930, Vol. 48, pp. 99–102.)

LE PROBLÈME DES HUILES ISOLANTES EN ÉLECTROTECHNIQUE (The Problem of Insulating Oils in Electrical Engineering).—H. Weiss and T. Salomon. (*Rev. Gén. de l'Élec.*, 12th and 19th July, 1930, Vol. 28, pp. 61–73 and 97–106.)

ÜBER DIE TRÄNKUNG VON ISOLIERSTOFFEN (The Impregnation of Insulating Materials).—M. Michailov. (*E.T.Z.*, 14th Aug., 1930, Vol. 51, pp. 1158–1160.)

THE RELATION BETWEEN GRAIN SIZE AND REMANENCE OF PURE IRON.—O. v. Auwers: G. J. Sizoo. (*Zeitschr. f. Phys.*, No. 7/8, Vol. 60, 1930, pp. 576–580.)

Cf. Abstracts, 1929, p. 50, 342 and 587; 1930, p. 351 and 352. The previous disagreement between the results of the two workers is here agreed to be due to experimental error, and the note shows the true significance of the influence of granular size.

DIE BERECHNUNG VON EISENDROSSELN MIT GROSSER ZEITKONSTANTE (The Calculation of Iron Cored Chokes with Large Time Constants).—F. Emde. (*Elektrot. u. Masch:bau*, 25th May, 1930, Vol. 48, pp. 521–530.)

CALMALLOY: A COPPER-NICKEL ALLOY WITH PERMEABILITY CHANGING LINEARLY WITH TEMPERATURE.—I. F. Kinnard and H. T. Faus. (*Journ. Am.I.E.E.*, May, 1930, Vol. 49, pp. 343–345.)

Hitherto unpublished data on this alloy are given by the writers in a paper on a "Self-compensating Temperature Indicator" for air-cooled aeroplane motors.

INSULATORS TESTED: (1) EBONITE.—W. H. F. Griffiths. (*Wireless World*, 2nd July, 1930, Vol. 27, pp. 7–9.)

The first of a series of articles to appear in this journal. The merit of each insulator is measured as a power-loss factor which is the product of power factor and permittivity, the latter term being better known as specific inductive capacity or dielectric constant. Ebonite with a power-loss factor of 0.025 (at medium to high radio-frequencies) is an approximate mean between good and bad insulating materials and for this reason forms a convenient standard of comparison. A chart on a logarithmic basis is given, showing that ebonite, while fifty times better than some of the worst insulating materials, is fifty times inferior to the best low-loss insulator known, *i.e.*, fused silica or Vitreosil. Disadvantages of ebonite are its softening at high tropical temperatures and its deterioration under continued exposure to actinic light.

INSULATORS TESTED: (2) KERAMOT. (*Wireless World*, 16th July, 1930, Vol. 27, pp. 63–64.)

Keramot is the trade name for a particularly good loaded ebonite. The softening produced in true ebonite at high temperatures is guarded against in Keramot by loading with minerals. These, unfortunately, impair its dielectric properties and at the same time increase its specific gravity, Keramot being 40 per cent. heavier than the pure product. The power loss factor of Keramot is approximately 0.05.

ÜBER DIE ELEKTRISCHE OBERFLÄCHENLEITFÄHIGKEIT VON PRESSBERNSTEIN (The Electrical Surface Conductivity of Ambroid).—E. Leiste. (*Zeitschr. f. Phys.*, 25th June, 1930, Vol. 62, No. 9/10, pp. 646–672.)

The substance in question is formed by a fusion process from small pieces of amber.

ELECTROCHEMICAL POWER PACK CONDENSERS (Aluminium Sheet and Gummed Fabric: Non-Hydroscopic).—E. W. Lincoln. (*Rad. Engineering*, May, 1930, Vol. 10, pp. 35 and 40.)

"High capacity is attained by a permanizing process which gives an exceedingly thin dielectric layer at the junction of the positive electrode and the gum layer. A true oriented molecular dimensioned, lattice structure comprises this surface on the prepared positive plate, and the contact couple acts as a capacitance junction, conduction occurring only on the movement of electrons held freely at the molecular boundary." The condenser is self-restoring.

VARIOUS RESEARCHES ON THE DIELECTRICS GLASS, QUARTZ, MICA, SULPHUR, PORCELAIN, ETC.—L. Inge, A. Walther and others. (*Journ. Applied Phys.*, Moscow, No. 6, Vol. 6, 1929.)

For abstracts of a number of these papers, see 1929 Abstracts, p. 281; 1930, p. 171 and 288; and *Phys. Berichte*, 15th July, 1930, pp. 1472–1473.

STATIONS, DESIGN AND OPERATION.

HET TECHNISCH ASPECT VAN DEN OMROEP IN NEDERLAND (The Technical Aspect of Broadcasting in Holland).—B. van der Pol. (*Tijdschr. Ned. Radiogen.*, June, 1930, Vol. 4, No. 5, pp. 105–127.)

Systematic field strength measurements were taken with a motor-transported equipment, and examined with the help of the writer's treatment of the Sommerfeld formula (*see* under "Propagation of Waves"). As a result, it is found that the effective radiation of Hilversum I (299 m.) is only about 110 w.; of Hilversum II (1,071 m.) about 470 w.; and of Huizen (1,875 m.) about 880 w. The small values for the two Hilversums are attributed to absorption in the immediate neighbourhood of the transmitters (buildings, etc.) On the basis of these results the author makes various recommendations to improve the service of broadcasting throughout Holland.

RADIO STATIONS CAN NOW BROADCAST NEAR OR FAR AT WILL.—Westinghouse Co. (*Rad. Engineering*, April, 1930, Vol. 10, pp. 42 and 49.)

Two methods for improving service:—(1) synchronisation of two or more stations on a common wavelength, and (2) a transmitting aerial system for increasing the strength of the local signal and at the same time minimising the amount of signal sent to a distance, or (conversely) to decrease the local and increase the distant signals.

DAS STATISTISCHE PRINZIP IN DER DRAHTLOSEN TELEGRAPHIE (The Statistical Principle in Wireless Telegraphy).—F. Schröter. (*Telefunk. Zeit.*, April, 1930, Vol. 11, No. 54, pp. 28–36.)

The "statistical principle" of interference elimination has as its ancestor the old plan of repeating the message and comparing the strips. A later development was the Verdan system (Abstracts, 1928, p. 406: 1929, p. 586); the writer's extension of this, using facsimile telegraphy, is here dealt with in considerable detail. The principle was described by him in 1928 (*see* 1929 Abstracts, p. 108).

RUNDFUNK AUF ULTRAKURZWELLEN? (Ultra-Short Waves for Broadcasting?).—A. Esau. (*Rad., B., F. f. Alle*, June, 1930, p. 284.)

A paragraph on a paper recently read by Esau in which he expresses his opinion that the future of Broadcasting lies with the ultra-short waves. He has apparently designed an additional unit which enables any ordinary receiver to be adapted to these waves. The German G.P.O. has been following his exhaustive tests on ultra-short waves with great interest and has recently given permission for an experimental broadcasting station (3 — 7 m.) to be set up in Chemnitz. It is admitted that these waves have very peculiar properties: thus while reception may be good in the east corner of a particular room, it may be impossible in the south corner of the same room. But Esau is very hopeful; if the Chemnitz tests are successful, they should lead to a revolution in Broadcasting and open up great possibilities for television.

THE MONOPHONE.—G. O. Squier. (*Journ. Maryland Acad. Sci.*, Jan., 1930, Vol. 1, pp. 1–7.)

An essay on the writer's system of wired wireless applied to broadcasting over the ordinary telephone network, "to deliver, with a degree of perfection not heretofore attained, super-programs into the home from the distributing telephone switchboards." The objection to the Monophone patent of 1926 has now been settled in his favour and the patent will issue shortly.

LA STATION DE RADIODIFFUSION DU CENTENAIRE DE L'ALGÉRIE (The Algerian Centenary Broadcasting Station).—(*Bull. S.F.R.*, No. 9, Vol. 3, pp. 200–219.)

"RADIO-NATIONS" ("RADIO-NATIONS": THE LEAGUE OF NATIONS TRANSMITTING STATION).—*QST Franç.*, March, 1930, Vol. 11, pp. 42–44.)

RADIO TELEPHONE SERVICE TO SHIPS AT SEA.—W. Wilson and L. Espenschied. (*Journ. Am. I.E.E.*, July, 1930, Vol. 49, pp. 542–546.)

Discusses the American end of the ship-to-shore radio-telephone system and the connecting equipment on board the "Leviathan."

SHIP-AND-SHORE TERMINAL EQUIPMENT: EQUIPMENT AND OPERATION OF THE BRITISH POST OFFICE STATIONS.—A. S. Angwin. (*Elec. Communication*, July, 1930, Vol. 9, pp. 56–61.)

PORTISHEAD SHORT WAVE TRANSMITTER.—A. J. Gill and A. G. McDonald. (*P.O. Elec. Eng. Journ.*, April, 1930, Vol. 23, Part 1, pp. 69–75.)

POSTE D'AVIONS, HYDRAVIONS ET AÉRONEFS TYPE A.V.L. 10 (Type A.V.L. 10 Set for Aeroplanes, Hydroplanes and Airships).—(*Bull. S.F.R.*, No. 10, Vol. 3, pp. 220–232.)

A continuous range from 450 to 1,500 metres is given by the transmitter, and more still by the receiver. The anode supply of the latter is at 24 v. only; that of the transmitter is from a small convertor driven off a 24 v. battery. This battery, and the propeller-driven generator charging it, usually form part of the lighting and heating equipment of the aeroplane. The above plan does away with the various disadvantages of a h.t. generator driven by propeller.

A MASTER OSCILLATOR OF HIGH CONSTANCY OF FREQUENCY.—Parkin. (*See* under "Transmission.")

GENERAL PHYSICAL ARTICLES.

ON THE BEHAVIOUR OF ELECTRONS AMONGST THE MOLECULES NH_3, H_2O AND HCl.—V. A. Bailey and W. E. Duncanson. (*Phil. Mag.*, July, 1930, Series 7, Vol. 10, No. 62, pp. 145–159.)

Authors' summary:—The problem of determining the statistical behaviour of electrons amongst molecules, to which they may become attached, has now been solved for those conditions where ionization by collision is absent and where the negative ions are permanent. The methods used and their application to the gases NH_3, H_2O and HCl are described in some detail, and are found to give consistent results for the energy of agitation of electrons, their velocity of drift, and their probability of attachment to molecules per unit distance of drift.

From these quantities have been deduced the values of the mean free path L of an electron in each gas, the fraction λ of its own energy which is lost and the probability h of its becoming attached when it collides with a molecule.

The results obtained from these and other experiments appear to show that λ bears some relation to the light absorbing power of the molecule, and that the probability h for a given kind of molecule varies considerably with the energy of the electron, generally increasing with its penetration into the molecule.

THE RECOMBINATION OF IONS IN AIR AND OXYGEN IN RELATION TO THE NATURE OF GASEOUS IONS: THE RECOMBINATION OF IONS IN ARGON, NITROGEN AND HYDROGEN.—O. Luhr. (*Phys. Review*, 1st June, 1930, Series 2, Vol. 35, No. 11, pp. 1394–1404: 1st July, 1930, Vol. 36, No. 1, pp. 24–34.)

THE ELECTRIC DOUBLE REFRACTION IN GASES.—J. W. Beams and E. C. Stevenson. (*Phys. Review*, 1st June, 1930, Series 2, Vol. 35, No. 11, p. 1440.)

THE MOBILITIES OF IONS IN DRY AND MOIST AIR.—J. Zeleny. (*Phys. Review*, 1st July, 1930, Series 2, Vol. 36, No. 1, pp. 35–43.)

For a previous paper *see* March Abstracts, p. 175.

UNTERSUCHUNGEN ÜBER DIE NATUR DER RÖNTGENSTRAHLUNG (Researches on the Nature of X-Rays).—J. A. Wasastjerna. (*Act. Soc. Scient. Fennicæ*, Helsingfors, No. 7, Vol. 1.)

CORPUSCULAR NATURE OF COSMIC RAYS.—L. F. Curtis. (*Sci. News-Letter*, 3rd May, 1930, Vol. 17, p. 274.)

Tests with two electron counters, one above the other, with a powerful electromagnet so placed as to deflect any charged corpuscle after it had struck the upper counter and before it reached the lower, showed that the cosmic rays are corpuscular in nature.

THE SIGNIFICANCE OF RECENT COSMIC-RAY EXPERIMENTS.—R. A. Millikan and I. S. Bowen. (*Proc. Nat. Ac. Sci.*, June, 1930, Vol. 16, pp. 421–425.)

The new experiments in question are (1) Millikan-Cameron work on cosmic ray absorption coefficients, (2) Millikan-Bowen experiments on the absorption of gamma rays in mountain lakes, (3) Chao's results on gamma ray absorption (*see* following abstract) and (4) Bothe-Kolhörster and Curtis tests with ion counters (*see* preceding abstract, also 1929 Abstracts, pp. 523 and 587).

THE ABSORPTION COEFFICIENT OF HARD GAMMA RAYS.—C. Y. Chao. (*Proc. Nat. Ac. Sci.*, June, 1930, Vol. 16, pp. 431–433.)

DIE STERNZEIT PERIODE DER HÖHENSTRAHLUNG (The Sidereal Time Period of the Cosmic Radiation).—A. Corlin. (*Naturwiss.*, 27th June, 1930, Vol. 18, No. 26, pp. 600–601.)

ÜBER DAS HERAUSSCHLEUDERN VON α-TEILCHEN AUS ATOMKERNEN RADIOAKTIVER STOFFE DURCH KURZWELLIGE STRAHLUNG (The Ejection of Alpha Particles from the Atomic Nuclei of Radio-active Substances by Short Wave Radiation).—G. I. Pokrowski. (*Zeitschr. f. Phys.*, 9th Jan., 1930, Vol. 59, No. 5/6, pp. 427–432.)

MISCELLANEOUS.

COMMUNICATION BY INFRA-RED WAVES.—Wigge and Wigand. (*Rad., B., F. f. Alle*, Aug., 1930, pp. 341–342.)

In discussing a recent paper read by the above workers, describing experiments in which communication has already been established over 5 km. through fog, it is suggested that the fact that music and speech can be transmitted (neon glow lamp) and received (cadmium cell) indicates that we must revise our ideas as to how the modulation is transmitted in wireless telephony—"since the infra-red light cannot be modulated and can only be made weaker or stronger."

PROPOSED NATIONAL SERVICE OF SCIENTIFIC RESEARCH IN FRANCE.—J. Perrin. (*Comptes Rendus*, 30th June, 1930, Vol. 190, pp. 1533–1534.)

BESCHLÜSSE DES INTERNATIONALEN BERATENDEN AUSSCHLUSSES FÜR TELEGRAPHIE. (Recommendations of the International Consultative Committee for Telegraphy—CCIT).—(*E.T.Z.* 17th July, 1930, Vol. 51, pp. 1035–1037.)

THE RADIO ENGINEER AND THE LAW.—P. M. Segal. (*Proc. Inst. Rad. Eng.*, June, 1930, Vol. 18, pp. 1038–1043.)

DAS HEINRICH - HERTZ - INSTITUT FÜR SCHWINGUNGSFORSCHUNG (The Heinrich Hertz Institute for Investigation of Oscillations).—K. W. Wagner. (*E.N.T.*, May, 1930, Vol. 7, No. 5, pp. 174–191.)

A description of the recently inaugurated Institute in Berlin.

CONTACT RESISTANCE AND MICROPHONIC ACTION. —Goucher. (*See* under "Acoustics.")

LE FONCTIONNEMENT DU REDRESSEUR À GALÈNE : POTENTIEL CRITIQUE (The Action of the Galena Rectifier : Critical Potential).—A. Stefanini. (*L'Elettricista*, Vol. 38, pp. 197–209 : Summary in *Rev. Gén. de l'Élec.*, 5th July, 1930, Vol. 28, pp. 16–17.)

Tests are described leading to the conclusion that (except possibly for very small currents) Pélabon's formulæ (Abstracts, 1928, p. 35 ; 1929, pp. 226 and 525) do not conform with experimental results. They do not allow for the existence of a critical potential, nor for the hysteresis phenomena observed by the writer and by Kallmeyer (1929 Abstracts, p. 588.)

LEUCHTERSCHEINUNGEN AM CARBORUNDDETEKTOR (Luminosity Phenomena with Carborundum Detectors).—B. Claus. (*Physik. Zeitschr.*, No. 8, Vol. 31, 1930, p. 360.)

Luminous effects at the electrodes are described ; they differ at the two poles not only in extent but also in the minimum voltage required to produce them. The writer applies these phenomena to the explanation of the rectifying effect. *Cf.* Lossev, Abstracts, 1929, pp. 53 and 588 ; 1930, p. 176.

UN INSTRUMENT TRANSPORTABLE POUR LA MESURE RAPIDE DE LA GRAVITÉ (A Portable Instrument for the Rapid Measurement of Gravity —using Photoelectric Recording).—F. Holweck and P. Lejay. (*Comptes Rendus*, 16th June, 1930, Vol. 190, pp. 1387–1388.)

AN INTERFERENCE METHOD OF MEASURING DISTANCE.—S. H. Chamberlain. (*Phys. Review*, No. 6, Vol. 35, 1930, pp. 663–664.)

Abstract only. A ray of white light is split into two parts which converge towards a distant mirror, whose distance is calculated from the spacing of the dark bands ultimately formed in an interference system.

DRAHTLOSE FERNLENKUNG VON FAHRZEUGEN (Wireless Distant Control of Vessels).—(*E.T.Z.*, 6th March, 1930, Vol. 51, p. 360.)

A reference to French tests with fast motor-boats on the Seine. Speeds attained reached 70 km. per hour ; the control arrangements were based on automatic telephone technique ; the 100 w. transmitter sent out a wave modulated at an intermediate frequency, signalling being by a varying number of 1/10 sec. dots. The receiver was provided with a filter tuned to the modulation frequency.

PROTECTION OF COMMUNICATION LINES AGAINST INTERFERENCE.—H. Geise and W. Plathner. (*AEG-Mitt.*, Nov., 1929, No. 11, pp. 714–723.)

THE HEAT-PUMP—AN ECONOMICAL METHOD OF PRODUCING LOW-GRADE HEAT FROM ELECTRICITY.—T. G. N. Haldane. (*Journ. I.E.E.*, June, 1930, Vol. 68, pp. 666–675, and subsequent Discussion.)

In the discussion, E. W. Marchant says : "Mr. Haldane's paper describes an arrangement whereby low-grade heat is obtained from an inverted refrigerator, and the experiments which the author has conducted at his house in Scotland are evidence that the scheme is practicable. It is remarkable that Lord Kelvin's suggestion of using a reversed compressor has never been adopted before : it is scientifically sound and enables the present disability of having only 24 per cent. of the thermal content of the coal available for heating purposes to be avoided. . . ."

THE APPLICATION OF LEAST SQUARES.—W. E. Deming. (*Phys. Review*, 15th March, 1930, Series 2, Vol. 35, No. 6, pp. 665–666.)

Abstract only of paper read before the American Physical Society, February, 1930.

EINE BEMERKUNG ÜBER DIE ANGENÄHERTE BERECHNUNG DES AUSDRUCKES $\frac{J_0(x)}{xJ'_0(x)}$ (A Remark on the Approximate Evaluation of the Expression $\frac{J_0(x)}{xJ'_0(x)}$.—W. Kessenich. (*Ann. der Physik*, Series 5, 1930, Vol. 5, No. 5, pp. 606–610.)

OPERATIONAL METHODS IN WIRE TRANSMISSION THEORY.—H. J. Josephs : O. Heaviside. (*P.O. Elec. Eng. Journ.*, April, 1930, Vol. 23, Part 1, pp. 60–68.)

ON THE PRINCIPLE OF HUYGHENS.—G. E. Uhlenbeck. (*Phys. Review*, 1st June, 1930, Series 2, Vol. 35, No. 11, p. 1439.)

Abstract only.

AMPOULE À RAYONS X DU TYPE COOLIDGE FONCTIONNANT SOUS LA TENSION DE 400,000 VOLTS (An X-Ray Tube of Coolidge Type working at 400,000 v.).—A. d'Arsonval. (*Comptes Rendus*, 30th June, 1930, Vol. 190, pp. 1538–1541.)

Description of a practical design of such a high-voltage tube, as contrasted to previous "laboratory" models. It carries 2 ma. for d.c., 2.5 ma. for a.c. Its success depends on "mounting the

filament in a metallic piece of rounded form" (of about 25 mm. diameter).

TECHNIK DES ELEKTRONENROHRENBAUES (The Technique of Electron Tube Construction).—A. Ungelenk and J. Wiehr. (*Zeitschr. V.D.I.*, 5th April, 1930, Vol. 74, pp. 431–436.)

A profusely illustrated article on modern X-ray tubes.

FORTSCHRITTE UND ENTWICKLUNGSMÖGLICHKEITEN AUF DEM GEBIETE DER LEUCHTRÖHREN (Progress and Development Possibilities in Gas-Discharge Lamps).—M. Pirani. (*E.T.Z.*, 19th June, 1930, Vol. 51, pp. 889–895.)

A communication from the Osram firm.

HIGH-VOLTAGE TUBES.—M. A. Tuve, L. R. Hapstad and O. Dahl. (*Phys. Review*, 1st June, 1930, Series 2, Vol. 35, No. 11, pp. 1406–1407.)

A short account of the construction and operation of Pyrex high-voltage tubes of the cascade type, which may be used for voltages of 1,000 to 2,000 kilovolts; internal shattering and puncturing is eliminated if the glass is "heat-worked" throughout.

EXPERIMENTELLE UND HISTOLOGISCHE UNTERSUCHUNGEN ÜBER DIE BLUTSTILLUNG DURCH HOCHFREQUENZSTROM (Experimental and Histological Researches on the Stanching of Blood by H.F. Currents).—K. H. Bauer. (*E.T.Z.*, 10th July, 1930, Vol. 51, p. 1017.)

Short summary of a paper read before the 1930 Congress of Surgeons in Berlin. This application of high frequencies "yields practically bloodless operations. Investigations into the mechanism are still lacking." But *cf.* Champy and Heitz-Boyer, March Abstracts, p. 177.

NEUERES ZUR ELEKTROBIOLOGIE (Latest Developments in Electro-Biology).—A. Schirmann. (*Elektrot. u. Masch: bau*, 23rd March, 1930, Vol. 48, pp. 269–271.)

REINIGUNG VON GASEN MITTELS ELEKTROFILTER (Purification of Gases by "Electro-Filters").—R. Heinrich. (*Zeitschr. V.D.I.*, 15th Feb., 1930, Vol. 74, pp. 193–199.)

An article, fully illustrated, on the commercial precipitation of dust, smoke, etc., by the use of high d.c. potentials. Either valve or mechanical (rotating) h.t. rectifiers are employed: the rotating rectifier for voltages of the order of 70,000 v. (5—30 kw.) referred to in 1928 Abstracts, p. 472, is discussed and illustrated.

THE "CATADYN" METHOD OF WATER STERILISATION.—(*Engineer*, 21st Feb., 1930, Vol. 149, p. 211.)

The bactericidal action of silver, explained by Lakhovsky (1929 Abstracts, pp. 405–406) as a "purely physical effect due to the change of frequency in the very high frequency oscillations in the core of each cell or microbe," has now been explained by Krause as a result of the metal accumulating active molecular oxygen: this generates metal salts which go into solution and kill the bacteria by transmission of the electric charge. Krause has been able to prepare silver in a special manner which greatly increases the speed of action, and the system is being introduced commercially under the above name. See below.

L'ACTION BACTÉRICIDE DES MÉTAUX (The Bactericidal Action of Metals).—G. Tammann. (*Génie Civil*, 22nd March, 1930, Vol. 96, pp. 292–293.)

Summary of a paper by this writer on Nägeli's discovery and its further developments (*cf.* preceding abstract). The action is due to the metal slowly dissolving in the oxygen-charged water.

In decreasing order of their bactericidal action the writer gives silver, antimony, nickel and cobalt. Gold and platinum do not dissolve, while the ions of tin, manganese, iron, etc., have no bactericidal powers.

DIE WIRKUNG ULTRAKURZER WELLEN AUF LEBEWESEN (The Effect of Ultra-Short Waves on Living Organisms).—H. Gunther: O.Schliephake. (*Rad., B., F. f. Alle*, Sept., 1930, pp. 420–425.)

An article based on Schliephake's various publications from 1926 to 1930. Some of his work has been referred to in Abstracts, 1929, p. 347, and 1930, pp. 176–177.

THE DIVINING ROD PROBLEM—AN ELECTRICAL-PHYSIOLOGICAL PROCESS.——. Buth. (*E.T.Z.* 14th Aug., 1930, Vol. 51, pp. 1171–1172.)

Tests have led the writer to conclude that water trickling in the earth leads to an electrostatic field in the air above, which produces discharge currents through the divining rod and causes contraction of the muscles of the hands. Fields produced by buried cables can be detected in a similar way. For an effect of short electric waves, *see* Heinrich, 1929 Abstracts, pp. 588–589.

SUR UN PROBLÈME DE CALCUL DES PROBABILITÉS AVEC APPLICATION À LA RECHERCHE DES PÉRIODES INCONNUES D'UN PHÉNOMÈNE CYCLIQUE (On a Problem in the Calculation of Probabilities, with Application to the Investigation of the Unknown Periods of a Cyclic Phenomenon).—N. St. Georgesco. (*Comptes Rendus*, 7th July, 1930, Vol. 191, pp. 15–17.)

In most interpolation problems it is supposed that only one of all the variables is subject to errors. The writer here deals with results obtained in linear interpolation in the case where all or part of the variables contain errors.

"BUSINESS CYCLES" (Alternations of Prosperity and Depression) AS AN EXAMPLE OF RELAXATION OSCILLATIONS.—van der Pol. (*See* abstract under "Properties of Circuits.")

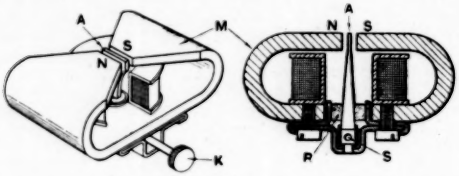
Some Recent Patents.

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

GRAMOPHONE PICK-UPS.

Application date, 22nd December, 1928. No. 326272.

The armature *A* is pivoted on trunnions *S* located outside the structure of the magnet *M*. The needle (not shown) is inserted axially and gripped by a set-screw *K*. As the armature in its neutral position carries no magnetic flux, it can be made of "Numetal" or other alloy of high permeability.



No. 326272.

The mounting is such that the armature and needle combined tend to balance about the fulcrum point, so that the damping and restoring means need not be unduly strong. The sensitivity is sufficient to allow a comparatively wide gap between the poles, thus permitting vibrations of large amplitude without causing distortion. A plug *R* of rubber or similar damping material is fitted into a tube near the fulcrum point, so as to act on the armature between that point and the free or upper end.

Patent issued to P. K. Turner and E. H. Robinson.

MAKING ARTIFICIAL PIEZO CRYSTALS.

Convention date (Germany), 21st December, 1927. No. 302726.

Finely divided quartz is subjected to the action of an electric field so that the separate particles are oriented. They are then held together by some binding material such as paraffin wax. Or they may be made to cohere by pressure, with or without heating. Each unit "crystal" is made in the form of a thin layer to facilitate mounting between electrodes in parallel or series.

Telefunken Gesellschaft fur Drahtlose Telegraphie m.b.h.

ELECTROSTATIC LOUD SPEAKERS.

Convention date (U.S.A.), 24th October, 1928. No. 326602.

An electrostatic loud-speaker, adapted for use with a push-pull amplifier, comprises two outer plates of conducting material separated by two sheets of dielectric, between which is inserted a central flexible conducting diaphragm. The output from the amplifier is applied across the outer rigid plates, the flexible diaphragm being connected to a suitable point of fixed potential.

Patent issued to United Reproducers Patents Corporation.

STABILISING S.G. VALVES.

Convention date (U.S.A.), 3rd May, 1928. No. 310940.

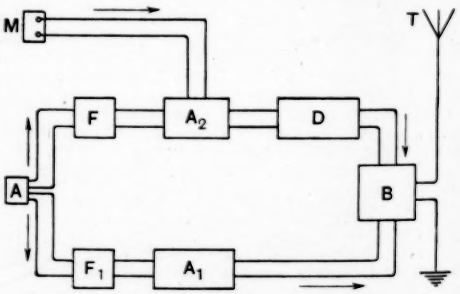
Residual capacity coupling between the leads and circuit elements in the input and output circuits respectively of a screened-grid amplifier is neutralised either (*a*) by suitably dividing the inductances in both circuits so as to obtain a "balancing" capacity feed-back, or (*b*) by splitting either the input or output inductance and deliberately adding a small balancing-condenser in a manner similar to that used for neutralising three-electrode valves.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

SIGNALLING SYSTEMS.

Application date, 8th April, 1929. No. 326375.

Although the instantaneous efficiency of 100% modulation may be as much as 64%, the average modulation is usually only one-fifth to one-third of the maximum modulation, and consequently the average power output during modulation is only of the order 1.05 to 1.1 times the carrier power. At the same time it may be necessary to expend approximately twice as much power as that of the carrier wave in order to avoid distortion. To secure a higher efficiency, the carrier wave and side-bands are separately amplified, and are afterwards recombined and transmitted from the same aerial; or they may be radiated from separate aerials. As shown in the figure a carrier-generator *A* is coupled on the one hand to a carrier-frequency amplifier A_1, and on the other hand to a balanced



No. 326375.

modulator A_2, in which the carrier wave is first modulated from a microphone *M* and the carrier wave then removed. The resulting side-bands are then separately amplified at *D*, and the two currents combined in a balanced bridge arrangement *B* feeding the aerial *T*. Filter networks *F*, F_1 prevent interaction between the two channels.

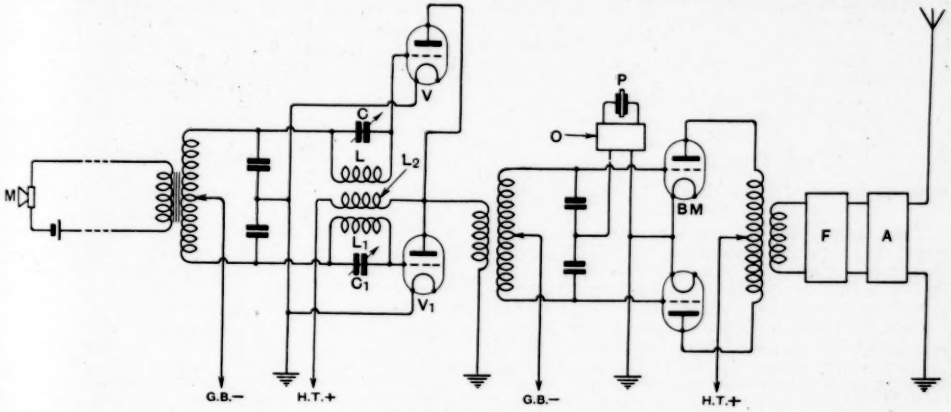
Patent issued to H. L. Kirke.

FREQUENCY MODULATION.

Convention date (U.S.A.), 23rd March, 1928. No. 308663.

Relates to frequency (as distinct from amplitude) modulating systems. Two valve generators V, V_1 comprise resonant circuits L, C and L_1, C_1, which are tuned to slightly different frequencies but are forced to oscillate at the same frequency by their common back-coupling through a coil L_2. With the same bias on the grids of both valves, the common frequency is the mean of the two resonant grid circuits. The effect of the modulating current from the microphone M causes the combined output from the valves V, V_1 to swing between the natural frequency limits of the two resonant grid circuits. The output is then applied to a balanced modulator coupled to a high-frequency oscillator O controlled by a crystal P. One of the resultant sidebands is separated out by a filter F and is passed to the aerial *via* a power amplifier A.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.



No. 308663.

LOUD SPEAKERS.

Convention date (France), 4th October, 1927. No. 298168.

The diaphragm is impulsed by a series of triangular-shaped members, the base of each triangle lying along the surface of the diaphragm, whilst the apices converge at the driving-rod. The diaphragm is made of very light material, such as goldbeaters skin. The triangular members are preferably made of Duralumin which propagates compression waves at high velocity.

Patent issued to L. Levy.

Application date, 12th November, 1928. No. 325227.

In order to adjust the angle between a vibrating reed and the face of the pole-pieces with which it is coacting, so as to secure optimum response, the reed is secured at one end to an elastic member, part of which is fixed with respect to the poles. Adjustable screws are then used to distort the elastic member in such a way as to vary, independently, both the position of the reed and the angle which it makes with the pole-face.

Patent issued to British Thomson-Houston Co., Ltd., and F. G. Arkell.

LIMITER VALVES.

Application date, 13th December, 1928. No. 324766.

A limiting action can be secured by running a triode valve with low filament emission. It is difficult, however, to secure adequate amplification in this way because interelectrode capacity prevents the use of several such valves in cascade. Also the use of neutralising or balancing devices is impracticable because the limited signal amplitude is usually comparable with the "carry-through" of the valve. According to the invention, the desired combination is secured by using several stages of screened-grid amplifiers in series and running alternate stages at a reduced filament temperature.

Patent issued to S. M. Smith.

RECORDING AND REPRODUCING SOUNDS.

Application date, 9th November, 1928. No. 324994.

The record is made by an electrode which is vibrated laterally by the sound current across the surface of a metal tape. A continuous arc discharge is maintained between the vibrating electrode and the tape, so that a sound trace is burnt into the surface of the tape. This is then filled in with finely-powdered magnetic material, such as iron or steel dust, and forms a "phonogram," which is then run in contact with a paper or non-magnetic tape so that the magnetic "trace" is transferred. Reproduction from the latter record is secured by running it through the field of a magnet having a winding in the input circuit of a thermionic amplifier coupled to a loud speaker.

Patent issued to A. F. and D. A. Pollock.

DAYLIGHT TELEVISION.

Application date, 21st December, 1928. No. 326836.

When an attempt is made to increase the definition of the produced image by increasing the number and reducing the size of the apertures in the scanning-disc, the image field at the receiver remaining constant, the image becomes obscured by an effect which resembles a snow storm. Any increase in amplification only results in further confusion. Increased illumination of the object overcomes the difficulty, but only when the intensity reaches a point intolerable to a human sitter.

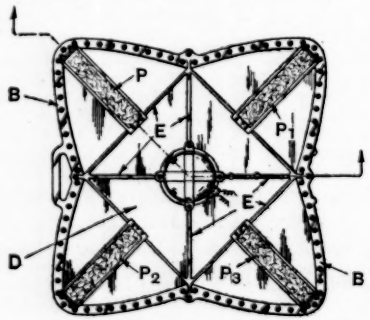
The invention provides an alternative scheme wherein a larger image field is attained by means of a suitable lens, all other factors remaining constant. With a lens having an aperture of 12.5 square inches, throwing an image of the field of view on the scanning-disc, television of outdoor scenes under normal daylight conditions has been secured, the degree of resolution being approximately that present in a square field of 2,500 elementary areas.

Patent issued to Western Electric Co., Ltd.

LOUDSPEAKERS.

Convention date (U.S.A.), 6th February, 1928. No. 305543.

The diaphragm preferably consists of an aluminium alloy rolled to a thickness of 0.002 inch and mounted under a tension of about 40 pounds per square inch. It is designed to operatemec hanically and acoustically as though it were of infinite size, though its actual dimensions may approximately be a square of 24in. size. The back reaction on the driving-motor is substantially zero within the working range of frequencies.



No. 305543.

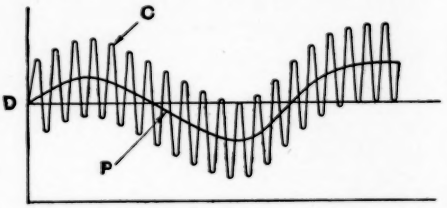
The diaphragm *D* is bolted to a peripheral supporting frame *B*, strengthened by cross-braces *E*. The edges are parabolic, and the driving impulses are impressed at the focal point of the parabola. The front of the wave reflected back from the periphery is a straight line perpendicular to the axes of the parabola. Damping-material such as wool or felt, is arranged along the reflected wave-front as shown at *P*—*P*3, so as to absorb most of the energy before undesirable reaction with outgoing waves can occur. The system is also applicable to a free-edge diaphragm associated with a baffle-plate.

Patent issued to V. A. Schlenker.

PICTURE-TRANSMISSION SYSTEMS.

Convention date (U.S.A.), 16th June, 1928. No. 313857.

Relates to " on and off " systems in which the signalling energy is transmitted at constant intensity, but is so interrupted into marking and spacing periods that the reproduced picture,



No. 313857.

although not continuously shaded, presents to the eye an apparent shading similar to that produced by ordinary modulation. In other words, the duration of the marking periods is proportional to the intensity of the modulated energy. This object is attained by applying to a control valve during transmission a grid bias such that the superposed signal waves serve to make the valve conductive only when the wave exceeds a predetermined mean value in amplitude. The line *D* represents the normal grid bias, the curve *C* a constant " interrupter or chopping " frequency, and the curve *P* a continuous current modulated in accordance with the light and shade of the transmitted picture. In operation the relay controlling transmission is actuated only during periods dependent upon the value of the modulated energy *P*.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

TELEVISION SYSTEMS.

Application dates, 19th January and 18th March 1929. No. 326603.

Advantage is taken of the fact that the human eye has a large field of view of comparatively indistinct vision combined with a small area of high definition. A plurality of separate images of a single scene are transmitted in such a way that at least one of the images has a wide field of rough definition, whilst at least another image is comparatively narrow in field but highly defined. In this way by transmitting two bands of, say, 40,000 cycles each, the same result is secured as could otherwise only be obtained by transmitting a wave-band of 400,000 cycles.

Patent issued to J. H. O. Harries.

OPERATING KERR CELLS.

Convention date (Holland), 2nd August, 1928. No. 316661.

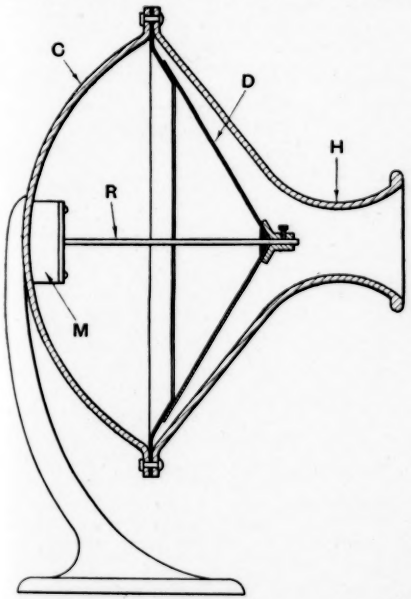
The functioning of a Kerr cell depends to a great extent upon the purity of the dielectric and its working temperature. It has been found that heating-up of the dielectric under working conditions is detrimental to its efficiency. According to the invention this source of trouble is eliminated by connecting the dielectric of the cell in a closed circulating-system, so that it is continually passing from the cell to a cooling-device and back again under thermo-siphonic action. A purifying-device may form part of the circulatory system.

Patent issued to N. V. Philips Glœilampen-Fabrieken.

LOUD SPEAKERS.

Convention date (U.S.A.), 22nd September, 1927. No. 297476.

A conical diaphragm driven by a rod R from the magnetic movement M is mounted in proximity to a concave casing C, to the periphery of which is attached a horn-shaped member H. Owing to the narrow angle between the sloping surfaces of the diaphragm and the horn, the free space is at all points small compared with the wavelength of the emitted sounds. The result is a comparatively



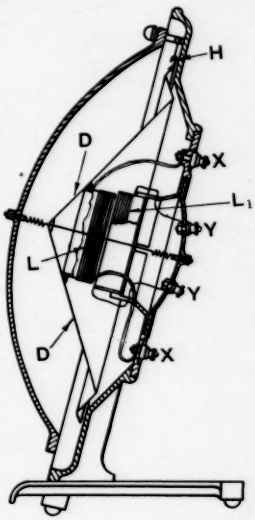
No. 297476.

large volume of sound, combined with an accentuation of the higher harmonics that are normally subdued when produced by a conical diaphragm.

Patent issued to Dubilier Condenser Co., Ltd.

Application date, 28th January, 1929. No. 326296.

Relates to a loud-speaker adapted to be operated directly by radio-frequency currents modulated at low frequency. The diaphragm D is carried by a number of spaced hooks H from a cord suspension system. A moving-coil L is carried on a cylindrical former attached to the diaphragm, the ends of the winding being brought out to terminals. A fixed coil L_1 is firmly mounted on the framework in close proximity to the coil L, and is connected across terminals Y, Y. In operation the unrectified output from a high-frequency amplifier is fed to the terminals X, X and the terminals Y, Y are shorted, so that a force of repulsion is set up between the primary and induced currents, thus impulsing the diaphragm in rhythm with the varying amplitudes of the H.F. currents. Alternatively the input may be applied to the terminals Y, Y and the terminals X, X shorted. Or both coils L and L_1 may be connected in series opposition.



No. 326296.

Patent issued to Mullard Radio Valve Co., Ltd., and B. Hodgson.

Application date, 24th January, 1929. No. 326614.

A moving-coil speaker is energised by a number of separate windings preferably arranged concentric with each other, but located in different planes, and on opposite sides of the diaphragm, so that at any given moment the driving-force comprises both a push and a pull.

Patent issued to M. Ward.

SECRET SIGNALLING.

Convention date (Germany), 18th February, 1928. No. 306420.

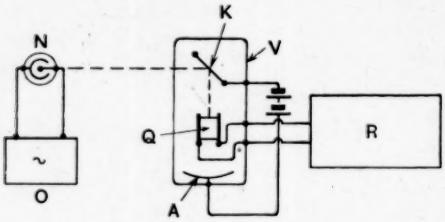
The signal oscillations are inverted in frequency-sequence by heterodyning, the component frequencies being transmitted alternately in the correct order and in reverse order (as a lower side-band). The alternations are effected by change-over switches so quickly that reception is not possible with ordinary sets. An authorised receiver is provided with change-over switches, which are operated in synchronism with those at the transmitting end by means of special control signals.

Patent issued to Telefunken Gesellschaft fur Drahtlose Telegraphie m.b.h.

LIGHT-SENSITIVE PIEZO-CRYSTAL SYSTEMS.

Application date, 1st December, 1928. No. 326498.

Light from a Neon tube N is modulated by a source O at a selected frequency, and is then applied directly to a piezo-crystal oscillator. Or it may be applied to the photo-sensitive electrode K of a vacuum tube V. The emitted electrons



No. 326498.

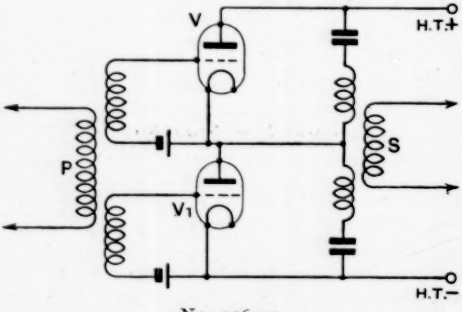
impinge upon a piezo crystal Q located between the electrode K and a positively charged anode A. The resulting crystal oscillations are applied to a tuned circuit R. A reactive back-coupling may be inserted between the circuit R and the initial source O of modulation. The method is applicable generally for the conversion of light into electrical energy, particular reference being made to the reproduction of sound from films.

Patent issued to J. Robinson.

THERMIONIC AMPLIFIERS.

Application date, 18th January, 1929. No. 326922.

Two valves V, V_1 are arranged with their plate-filament paths in series across a common high-tension source, and the input P is applied so that as the impedance of one plate-filament path increases that of the other decreases, and *vice-versa*, giving a push-pull effect on the load S and a constant-current drain on the H.T. supply. If the



No. 326922.

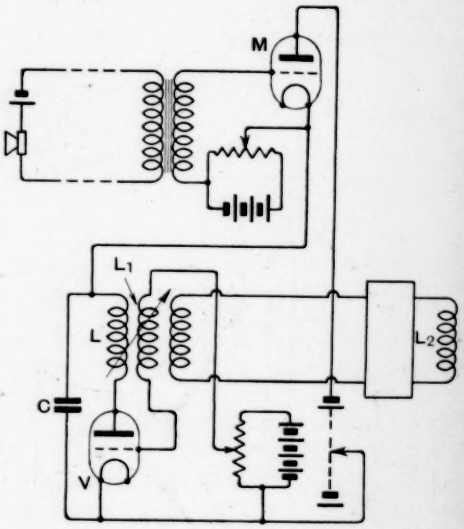
input voltages are applied in inverse proportion to the "μ" factors of the valves, (*a*) the input and output voltages are maintained in straight-line relation so that there is no wave-form distortion or production of harmonics, and (*b*) the H.T. supply is kept constant and free from "hum" or audible-frequency components. Accordingly a source of H.T. of high internal impedance may be used to supply several valve stages in cascade without the necessity of using special de-coupling devices. Finally only sufficient "smoothing" is required to prevent the valves from being driven off the straight-line part of their characteristics.

Patent issued to P. K. Turner.

FREQUENCY-MODULATION SYSTEMS.

Convention date (U.S.A.), 23rd March, 1928. No. 319336.

Oscillations are generated at a frequency which is independent of any resonance effect and is governed solely by the time taken to charge a condenser C to a critical value. The plate and



No. 319336.

grid circuits of the valve generator V are coupled together through the coils L, L_1. The plate potential is applied through a modulating valve M. As the condenser C charges up, current begins to flow through the valve, and the induced voltage through the coil L_1 accentuates the flow. As soon as the charging current starts to decay the grid acquires a negative charge and so accelerates the cut-off. In this way the valve is "tripped" into and out of action at a definite frequency, which is governed solely by the magnitude of the charging current. This in turn is controlled by the modulating valve M under the influence of the applied currents from the microphone. The output coil L_2 is coupled to a balanced modulator for single side-band transmission.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.